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Development and Application of a Risk Assessment Method for Radioactive Waste Management Volume III: Economic Analysis; Description and Implementation of AMRAW-B Model

New Mexico Univ, Albuquerque. Bureau of Engineering Research

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Development and Application of a Risk Assessment Method for Radioactive Waste Management

Volume III: Economic Analysis; Description and Implementation of AMRAW-B Model

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16. ABSTRACT

A Radioactive Waste Management Systems Model, developed and implemented by The University of New Mexico under contract with the U.S. EPA, is presented. The systems model and associated computer code called AMRAW (Assessment Method for Radioactive Waste), has two parts. The first part, AMRAW-A, consists of the Source Term (radioactive inventory versus time), the Release Model, and the Environmental Model. The Release Model considers various geologic and man-caused events which are potential mechanisms for release of radioactive material from a repository or other location of emplacement. The environmental model describes the transport to and accumulation at various receptors in the biosphere, the transfer to man via various pathways, and the resulting radiation does. The systems model can be run in either of two modes determined by the manner in which postulated release events are assumed to occur. Release events can either be treated as discrete events occurring at specified times, or as probabilistic events distributed over time. The second part of the systems model, AMRAW-B, the Economic Model calculates health effects corresponding to the various organ dose rates from AMRAW-A, collects these health effects in terms of economic cost and attributes these costs to radionuclides, decay groups, and elements initially in the waste inventory. The implementation of AMRAW for terminal storage in a bedded salt reference repository is described and the application to a reference repository in a shale formation is discussed. Application to the repository operations phase and to the analysis of disposal of nonradioactive hazardous materials is also discussed.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
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Risk Assessment-Mathematical Model	Geologic Disposal	1202
Nuclear Fuel Reprocessing	Assessment Methodology	1810
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DEVELOPMENT AND APPLICATION OF A RISK ASSESSMENT METHOD FOR RADIOACTIVE WASTE MANAGEMENT

Final Contract Report

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Volume III: Economic Analysis; Description and Implementation of AMRAW-B Model

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FOREWORD

The EPA Office of Radiation Programs carries out a national program to evaluate human exposures to radioactivity, and to promote the development of controls to protect the environment and public health from such radioactivity. An important part of this program consists of the development of environmental protection criteria and standards for radioactive waste management and disposal.

To sustain this effort, studies have been supported by EPA to develop methods to evaluate the environmental adequacy of proposed waste management alternatives, and this report describes one of the first attempts to develop a comprehensive assessment model. It has been funded at a very modest level. Much interest has been expressed in this work, and through publication, EPA is making it available to those involved with the development and use of models as decision-making tools.

In order for models to be useful as tools for decision-making concerning radioactive waste management alternatives, their capabilities and limitations must be fully understood. It should be noted that assessment models in themselves will not identify optimum waste management choices. However, they can be used to compare well defined alternatives. One of the necessary steps in any model development and validation process is the comparison of results with results obtained from the application of alternate models to test cases. It is hoped that as other comprehensive assessment models become available, comparison studies can be performed.

The methodology described herein has been applied, for model illustration purposes, to a reference repository in a bedded salt formation located in the southwestern United States. Any results published in this report should not be interpreted as implying conclusions concerning the suitability of the reference site or any site-specific method/repository combination for the preparation and disposal of radioactive waste.

Comments on this analysis as well as any new information would be welcomed; they may be sent to the Director, Technology Assessment Division (AW-459) Office of Radiation Programs, U.S. Environmental Protection Agency, Washington, D.C. 20460.

W. D. Rowe, Ph.D.
Deputy Assistant Administrator
for Radiation Programs (AW-459)

ABSTRACT

A Radioactive Waste Management Systems Model, developed and implemented by The University of New Mexico under contract with the U. S. Environmental Protection Agency, is presented. The systems model and associated computer code called AMRAW (Assessment Method for Radioactive Waste), has two parts. The first part, AMRAW-A, consists of the Source Term (radioactive inventory versus time), the Release Model, and the Environmental Model. The Release Model considers various geologic and man-caused events which are potential mechanisms for release of radioactive material beyond the immediate environs of a repository or other location; the risk analysis mode uses events distributed probabilistically over time, and the consequence analysis mode uses discrete events occurring at specified times. The Environmental Model includes: 1) the transport to and accumulations at various receptors in the biosphere, 2) pathways from these environmental concentrations, and 3) resulting radiation dose to man.

The second part of the systems model, AMRAW-B, is the Economic Model which calculates health effects corresponding to the various organ dose rates from AMRAW-A, collects these health effects in terms of economic costs and attributes these costs to radionuclides, decay groups, and elements initially in the waste inventory. Implementation, with calculated results, of AMRAW for Terminal Storage in a Bedded Salt Reference Repository are presented. Preliminary demonstrations for the repository operations phase of waste management and terminal storage in a shale formation are described; possible applications to other radioactive and nonradioactive hazardous materials are discussed. AMRAW uniquely links all steps together in a continuous calculation sequence.

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During early phases of the study, A. V. Kneese of the UNM Economic Department provided helpful suggestions in the area of Environmental Economic Modeling. Personnel at UNM who participated in the project, and other persons making direct contributions are named in the Acknowledgements section of Volume I.

DEVELOPMENT AND APPLICATION OF A RISK ASSESSMENT METHOD FOR RADIOACTIVE WASTE MANAGEMENT

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VOLUME I	GENERIC DESCRIPTION OF AMRAW-A MODEL
VOLUME II	IMPLEMENTATION FOR TERMINAL STORAGE IN REFERENCE REPOSITORY AND OTHER APPLICATIONS
VOLUME III	ECONOMIC ANALYSIS; DESCRIPTION AND IMPLEMENTATION OF AMRAW-B MODEL
VOLUME IV	AMRAW COMPUTER CODE USERS' MANUAL

VOLUME III

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VOLUME III

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

CHAPTER 1

AMRAW	(Assessment Method for Radioactive Waste) Assessment Model and associated computer code
AMRAW-A	That portion of AMRAW which includes Source Terms, Release Model and Environmental Model
AMRAW-B	The economic part of AMRAW

CHAPTERS 2, 3, AND 4

None

CHAPTER 5

C.V.	Compensating variation
D	A vector of increased risk of death per 0.1 rem per 10^6 population
E.V.	Equivalent variation (present value of future earnings)
G(¶)	Production function
L	Lagrange function of expected utility
M	Market measure of risk
M_k	A matrix of doses for the kth zone in millirems per person in the tth time period for the ith nuclide, impacting the jth organ (i=1, ... 25) (j=1, ... 7) (k=1, ... 8)
N_k	Population in the kth zone in time t
P	Price of final output
PR	Profit function
r	Interest rate
S_1, S_2	Overall market relationship between wages and risk, less skilled and highly skilled labor, respectively

t	Time
TD_k, TD_{ik}	A vector representing deaths associated with the dose from each nuclide in the kth zone in time t
$u(W)$	Utility function of wage
W	Amount of wage earned
W^*	Wage earned in risk-free job
π	Risk factor (probability of being killed on the job)
λ	Lagrangian multiplier

CHAPTER 6

man-rem	Unit of dose used for "nonspecific" dose (committed dose equivalent to an undefined population from consumption of largely exported agricultural products)

CHAPTER 7, 8, AND 9

None

CHAPTER 10

MT	Metric tons
MWd/MT	Mega-watt days/metric ton - a measure of fuel burnup
MW(e)	Mega-watt electrical

APPENDIX A

c_o	Constant accounting for genetic damage
c_1	Constant accounting for decrease in genetic damage
m	Dose in rems to individuals
$m_k(t)$	Aggregate population dose for Zone k around repository in time t

t	Time
TD_k, TD_{ik}	A vector representing deaths associated with the dose from each nuclide in the kth zone in time t
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$m_k(t)$	Aggregate population dose for Zone k around repository in time t

r	Interest rate
R	Risk of increase death/10^6 population
t	Time
T	Present value of discounted net benefits
v	Unit productive value
z	Dollar cost of excess risk per genetic death

CHAPTER 1

INTRODUCTION

The Radioactive Waste Management Systems Model and associated computer code, AMRAW, developed at The University of New Mexico (UNM), beginning in 1972 [Lo74a], consists of two parts which are run separately: 1) AMRAW-A consists of the Source Term, Release Model, and Environmental Model, and 2) AMRAW-B is the Economic Model which includes determination of health effects and calculation of corresponding damages in terms of economic units. Dose equivalent rates calculated by AMRAW-A are input to AMRAW-B. The model applies to any of the several phases in the radioactive waste management sequence, although most of the effort during this study, has been related to the terminal storage (disposal) phase.

As part of the generic model development work, an application to terminal storage in a bedded salt model repository has been completed. The development of an application in parallel with development of the model helped in: 1) identifying model provisions necessary to accommodate real situations, 2) providing a demonstration of the procedure for applying the model to any site, 3) provided some useful output for waste management planning, and 4) accumulated a data bank which includes site-specific and non site-specific components.

This volume describes AMRAW-B, the Economics Model, and is in two parts: Part 1 presents a generic description of the AMRAW-B model, background economic theory and a description of the AMRAW-B computer code, and Part 2 presents implementation of the model with an application to terminal storage in a bedded salt reference repository. The site chosen for this initial application is the Los Medaños area in southeastern New Mexico, an area under study for potential installation of a Waste Isolation Pilot Plant [Wr77]. The proposed pilot plant is for DOE trans-uranium waste and experimental retrievable implacement of some high-level waste. There are no plans at the present time to expand this facility into a full scale high-level waste repository but the application of AMRAW reported here assumes it is a full scale repository

for study purposes. A base case which simultaneously considers several release scenarios is first described in detail in Part 2 along with calculated results. This is followed by other cases which examine discrete release events and variations of selected parameters.

Calculated results from the demonstration application to a specific site are useful for several purposes including the following:

1) Determine behavior at each stage through the model: calculated releases from the repository, environmental concentrations, and dose equivalent rates to the population (AMRAW-A), and health effects and associated damages (AMRAW-B).

2) Determine relative importance of each environmental input receptor: air, land surface, surface water, and ground water (AMRAW-A).

3) Select the most significant radionuclides and elements under various circumstances.

4) Determine effects of variations in parameters which have large uncertainties.

5) Study the consequences of various low-probability potential release scenarios.

The costs presented from this study do not represent total costs; costs for construction of a waste repository and associated waste treatment, transportation and emplacement costs are not included. The costs presented here are the long term costs arising from health effects due to postulated release events and provide an important component of total cost estimates. Due to uncertainty in values of some input parameters, the calculated costs should by used primarily for comparisons of various waste management options instead of used as absolute representations of damage costs.

CHAPTER 2

SUMMARY

The generic description of AMRAW-A and implementation of the model and computer code for terminal storage in a bedded salt reference repository is presented in other volumes. This volume describes AMRAW-B, the Economics Model.

Part 1 presents a generic description of the AMRAW-B model and computer code. The first section of this model is concerned with incidence rates of health effects associated with radiation dose to various body sites (organs). In this report, dose refers to dose equivalent or more specifically, committed dose equivalent from exposure to radiation. The BEIR report [NAS72] is used as the source of information for incidence rates (deaths/10^6 man-rem) of: 1) leukemia, 2) cancers (G. I. tract including stomach, lung, bone, breast, and remaining cancers as a group), and 3) genetic effects. These are related to dose to specific organs for which AMRAW-A calculations are made. Leukemia relates to bone marrow dose, G. I. tract to G. I. tract dose, lung to lung dose, bone to bone dose, and genetic effects to gonad dose. Dose to breast is not presently calculated by AMRAW-A (dose conversion data is not found for this site); therefore, breast cancer and remaining cancers are related to total body dose as an approximation. The incidence rate for serious genetic effects is taken to be the log mean value for a 25 to 1 range, adjusted for the fraction of the population who become parents.

The last section of the Economic Model is concerned with evaluation of totaled health effects in terms of economic units. Economic concepts of present value of future damages and discounting are presented. In this study, a zero discount rate is used, but the model has the capability of applying non-zero rates if this becomes justified. The economics of risk are reviewed. The term "risk" in this volume, unless otherwise qualified, refers to the chance of damage or loss. Elsewhere in this study, risk is defined as the product of annual probability of occurrence of an event and the consequences of an occurrence. A dollar value of increased risk of death is developed in terms of the dollar value of a

small increase in risk around an existing value. Thus, a $260 per year value of a 0.001 change in annual risk of death indicates a value of $260,000 per statistical death. It is important to note that this is not a measure of the value of life but of risk of death appropriate for small changes in that risk. There will likely be misinterpretations of results of this study by persons taking portions out of context. A number of deaths and corresponding dollar valuation of damages calculated by AMRAW-B refers to small changes in risk to large populations already exposed to large risk from other existing sources. For demonstration purposes, this study assumes occurrence of events which likely will not occur within a 10^6 y time frame.

The AMRAW-B computer code is described. This code receives as input: dose rate output from AMRAW-A, health effect incidence rates, economic parameters, and code operation parameters. Output is a series of tables giving damage rates, statistical rates of death from health effects, and integrated totals over the time range studied. Results are broken down by geographic zone and a nonspecific category, and by radionuclide. Local damages are associated with radiation dose to the population in each geographic zone and the nonspecific category is associated with agricultural products grown in the region but largely exported and consumed by a nonspecific population.

Part 2 presents implementation of the model for terminal storage in a bedded salt reference repository. The site chosen for this initial application of AMRAW is the Los Medaños area in southeastern New Mexico. This area is in a stable region, has thick deposits of nearly horizontal bedded salt (Salado Formation), and is under study for potential installation of a Waste Isolation Pilot Plant [Wr77]. The proposed pilot plant is for DOE trans-uranium waste and experimental retrievable emplacement of some high-level waste. There are no plans at the present time to expand this facility into a full scale high-level waste repository. The application of AMRAW reported here assumes for study purposes that there is only one repository for commercial high-level waste and that it is located at Los Medaños. Concentration of the total waste inventory at one site represents a conservative case for demonstration of the assessment methodology; division of the total inventory into several different repositories reduces the risk associated with any one site.

The site and surrounding region is characterized for two categories of information: 1) geologic and hydrologic features of the area provides a base for evaluation of potential release events, and 2) demographic and agricultural data within a radius of approximately 150 km from the site provides for calculation of consequences of any release. The study region is divided into 8 zones along county boundaries with one or more counties in each zone. Exceptions are Zone 1 which is defined as a 5 km radius area enclosing the site, and Zone 8 which is defined as a corridor through Eddy County along the Pecos River having irrigated land.

The base case is the primary vehicle used here for implementing the model. Other cases draw from the base case input data with appropriate variations. The base case, run in the probabilistic mode, represents operation in a risk mode where risk is defined as the product of probability of occurrence of an event and the consequence of the event if it occurs.

A first step in implementing the model is to select the number of time increments and the duration of each. Here, 50 increments are used over a total time range of 10^6 y; this permits each output table to be complete on one page of computer printout. The first six time increments (5 y each) from zero reference time through the increment ending at 30 y cover the repository operations phase. The next increment, of 10 y duration ending at 40 y reference time, starts the terminal storage phase. The size of the time increments is increased in steps at later times to reduce computer requirements. Also selected initially are the radionuclides to be evaluated (25 here), the geographic zones (8 here), and the human organs for which dose is to be calculated (8 here, including total body).

Source Term data is prepared externally to AMRAW. This is a matrix of grams of inventory of each selected radionuclide at each of the specified times. For this application, an underground repository area is assumed to be 10 km^2 which provides for accumulation of waste from reprocessing of 187,000 metric tons of spent fuel. This quantity applies to a 30 y accumulation for the moderately low growth case [Bk76, ERDA76] or slightly less than a 40 y accumulation for the low growth case [Ax77]. One hundred, eighty-seven thousand metric tons of fuel at a burnup of

33,000 megawatt-days (thermal) per metric ton and a thermal efficiency of 0.325 represents electrical energy generation of 5500 GW-y or 4.8 x 10^{13} kw-hr. This data reflects a projection of installed nuclear capacity and reactor types, the step-by-step accumulation during the repository operations phase, simple decay, and chain decay, including ingrowth of daughters.

The base case is run in the probabilistic mode in which several types of geologic disturbance events are considered: severe earthquake, volcanism, meteorite impact, and surface erosion.

The most likely geologic event for disturbance of the repository assumed for this assessment demonstration appears to be offset faulting which could interconnect aquifers above and below the bedded salt formation. The annual probability of such faulting is estimated to be 1.4 x 10^{-7}. Subsequent slow leaching and retardation in ground water flow combine to delay and mitigate consequences of such an event. A volcanic explosion, assumed to transport 50% of the intercepted waste inventory into the air but estimated to have an extremely low probability for occurring within a repository zone (2.4 x 10^{-12} per year), and volcanogenic transport to the ground surface (8.1 x 10^{-12} per year) are the events which make the major contributions to the results calculated on a probabilistic basis. While the method assigns some risk from volcanic explosion, it should be noted that the low probability means there is only one chance in 400,000 that such a volcanic event would expel material at any time during a one million year storage period.

Results obtained by AMRAW-B for the base case indicate total damages integrated over a period of 10^6 y of \$1.26 x 10^9 for the high and \$8.15 x 10^8 for the low population projections, representing average damage rates of \$1,260 and \$815 per year respectively. While the calculated damages represent a comparison index for different waste management alternatives and do not represent predictions of absolute damage costs, it is of some interest in gaining a perspective view to determine marginal damages on various bases. Examples of values obtained for the high population projection are \$0.20 per gram of radioactive isotopes in the initial waste inventory ("initial" here refers to the beginning of terminal storage), \$160,500 per reactor -y, and 0.026 mills/kw-hr of electric energy.

Following the base case, a series of other cases for discrete release events is described and the results are presented. Volcanic explosion releases to air at 10^3, 10^4, and 10^5 y reference times are examined with the conservative assumptions that one-half of the repository inventory intersected by the volcano becomes expelled and is not reburied. Severe levels of calculated damages are obtained for such an event. However, the probability of occurrence is estimated to be only 2.4×10^{-12} per year. A token value for the environmental decay constant, representing an environmental half-time of 30,000 y, is used. Data is not available at this time to support use of the much lower environmental half-times, which probably do obtain. An increase in the value for the environmental decay constant by a factor of 100, made for one case, reduces the calculated damages by a factor of 20. As expected, later occurrences of a volcanic event reduce damages.

Another case examines a leach incident associated with offset faulting from a severe earthquake, commencing at 100 y. For the sorption properties used, only C-14, Tc-99, I-129, and Np-237 appear at a distance of 10 km within 10^6 y. The ground water velocity used was conservatively taken as 6 times the estimated value, to cover uncertainty. On this basis, Np emerges after 800,000 y and contributes significantly to the calculated damages. A slightly less conservative assumption for velocity would delay this Np contribution until after the 10^6 y time range studied.

The most significant radionuclides and elements are ranked at various times and on bases of total damages and damage rates. Approximately two-thirds of the 25 selected nuclides studied become listed among the 5 most significant in one or more instances. A simple scheme is presented which attributes total damages to precursors initially present in the waste inventory. This identifies those isotopes which should be minimized in waste inventory for the purpose of reducing potential long-term damages. With present technology, management decisions can be exercized only with regard to chemical elements and not by specific nuclides. After attribution of total damages to precursor nuclides and accumulation of the latter by element, it is found that, in general, virtually all of the calculated damages may be attributed to

only 4 elements: Am, Np, Pu, and Tc. Under some circumstances, Cm also contributes. Separation of actinides and Tc from spent fuel and transmutation in a reactor therefore can significantly reduce the risk from terminal storage. Results regarding the most significant nuclides and elements are sensitive to repository site parameters, waste inventory emplaced, demographic data for the region surrounding a repository site, and the release scenarios considered.

CHAPTER 3

CONCLUSIONS

There are two groups of conclusions presented in this volume. The first group refers to the development of the AMRAW model and computer code; the second group refers to the implementation of the model to terminal storage in a bedded salt model repository. Conclusions from development and implementation of AMRAW-A (Source Term, Release Model and Environmental Model) are presented in Vol. II.

The AMRAW-B part of the overall model continues the interdisciplinary character of AMRAW, which successfully brings together results from several fields of study for technology assessment of each phase of radioactive waste management. AMRAW-B interfaces with dose rate output from AMRAW-A and uses input data for health effect incidence rates and economic parameters to calculate health effects and the corresponding damages in economic units. The two parts of AMRAW can be linked together for a continuous run, but it has been convenient to maintain them separately for development purposes and parametric studies. AMRAW-B is flexible and will accommodate the number of time increments, number of geographic zones, number and selection of body sites (organs), and number and selection of radionuclides as used for the dose rate matrix obtained from AMRAW-A. A major function fulfilled by AMRAW-B is to take dose rates which vary over all of the zones and organs considered, and converge these to values of damages which include weighting for the population in each zone, and incidence of health effects associated with each organ. These damages can then be attributed back to radionuclides and elements in the waste inventory at the time the repository accumulation is completed.

Implementation of the model to terminal storage in a bedded salt model repository leads to numerous findings. First, consider the base case, run in the probabilistic mode. This case considers several types of geologic disturbance events: severe earthquake (leading to possible leach incident), volcanism, meteorite impact, and surface erosion. Each conclusion reached may be altered as new data becomes available and each

might or might not apply to a different site.

1) The total damages over a one-million-year period are calculated to be $1.26 x 10^9 for a high population projection and $8.15 x 10^8 for a low population projection. The corresponding statistical deaths from health effects are 4,840 and 3,130, respectively. This represents average annual rates for high population of $1,260 and 0.005 deaths.

2) The calculated damages are not a prediction of absolute costs, as they are obtained by a probabilistic-allocation of disruptive events over all time though it is unlikely that they would occur within the time period studied.

3) The calculated damages serve as an index for comparing different waste management alternatives, and identification of the most significant contributors to damages. While not an absolute prediction, the marginal damages for the high population condition become 0.026 mills/kw-hr of electric energy.

4) The nonspecific category of damages, associated with largely exported agricultural products, is limited by available irrigation water and grazing land capacity, and is not affected by population. Nonspecific damages comprise 46% of the total for the high population projection and 70% of the lower total for low population.

5) Genetic effects make up approximately 6% of the total from somatic and genetic effects. There is an uncertainty range of a factor of 5 above and below the log mean genetic incidence rate. Genetic therefore has a range of 1.3% to 24% of the total, with the more probable value being 6%.

6) Of the 25 selected radionuclides, 16 appear among the 5 most significant at some time during the time range studied. Over the full 10^6 y period, the most significant contributors to total damages, in order of importance (highest first) are: Np-237, Tc-99, Ra-226, Th-229, and Ra-225. After attribution to precursors initially present, the most significant become: Np-237, Tc-99, Am-241, Pu-238, and Am-242m.

7) Designation of the most significant radionuclides and elements depends heavily upon the time frame over which calculations are made, the release scenarios considered, and the basis used for ranking.

8) After attribution of total damages to precursor nuclides and accumulation of the latter by element, virtually all of the calculated damages are attributed to only 4 elements: Am, Pu, Np, and Tc. Any management concept which reduces one or more of these will significantly reduce the risk from terminal storage of waste.

Other conclusions relating to relative importance of the 4 environmental receptors, release events, and site and hydrologic parameters are presented for AMRAW-A in Vol. II.

Extension of the base case through application of AMRAW-B to several cases of discrete release events occurring at various times leads to additional conclusions.

1) Total damages accruing after a volcanic explosion through the repository decrease as the time of occurrence becomes later. Damages for such an event are severe but must be weighted by the extremely low probability of occurrence.

2) Damages for a leach incident accrue primarily to 4 elements in order of importance (highest first): Np, Am, Tc, and Pu.

The total damages and marginal damages obtained in the demonstration applications are based upon emplacement of all of the high-level waste from reprocessing of spent fuel from 7,850 reactor years of operation in a single repository. Damages associated with an individual repository are reduced if multiple repositories are used. Damages are greatly dependent upon actinide and technetium content of the waste. More complete separation of Pu for recycling, plus separation of Np and Am in addition for transmutation, reduce damages. On the other hand, disposal of spent fuel as waste greatly increases the actinide content and correspondingly increases long-term damages from the terminal storage phase.

CHAPTER 4

RECOMMENDATIONS

Specific recommendations are discussed in Vol. II concerning improvement of data for geologic and man-caused release events, hydrologic transport, environmental persistence following dispersal, resuspension behavior and other factors. Recommendations are given here which apply specifically to AMRAW-B. In addition, some general recommendations for model applications are repeated for convenience of the reader.

The systems model and computer code, AMRAW, are operational. There will always be improvements in the model which can be made, and there will never be as much data or data as accurate as the user of the assessment method would like to have. Also, there will continue to be uncertainty with prediction of geologic events. Certain areas of data need attention as shown by this study. Additional applications of the model and further study of calculated results will be helpful in understanding the most important contributors to risk from waste disposal, and defining the ways to minimize the risk. However, caution should be exercised to avoid non-ending studies prior to completing assessments and making decisions to resolve radioactive waste management questions.

Recommendations for additional computer programming provisions in the AMRAW-B code follow.

1) Establish a scheme for attribution of damages to precursor radionuclides and elements which is more rigorous and which may be applied to total accrued damages at any time instead of late in a 10^6 y period.

2) Provide for running attribution calculations at intervals over the entire time range to more clearly show the shift of attributed damages and associated marginal damages with time.

3) Provide for additional or alternate output tabulations as suggested after wide reviews of the results from this study are made.

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There are several types of AMRAW applications recommended for futher work. The model should be applied to various proposed repository sites in different geologic media: shale, basalt, granite, and dome salt. Different emplacement methods such as a drilled hole matrix and conventional mining may affect the results and should be investigated. An application which can help to place results obtained to date into perspective is the calculation of risk associated with an undisturbed uranium ore body. This is a naturally radioactive "repository" of low concentration but having a large area. Responses to assumed releases without fully characterizing the release mechanism can be helpful in comparing different demographic or agricultural settings, various environmental pathways, or movement via ground water. Extension of sensitivity analysis is recommended to further bracket the important ranges of significant parameters.

Unreprocessed spent fuel disposed of as high-level waste would increase the environmental risk from the terminal storage phase due to: 1) increased volume of waste which increases total repository area required, 2) large increase of plutonium in the waste inventory, and 3) increased thermal energy release and continuation of thermal effects over long time periods which accentuates this perturbation. Also, unless some processing is done to incorporate the material in a leach resistant matrix, the waste form is more susceptible to releases by leaching. The long term environmental risk of spent fuel as waste should be assessed.

PART 1

AMRAW-B MODEL AND COMPUTER CODE

CHAPTER 5. GENERIC DESCRIPTION OF AMRAW-B MODEL

CHAPTER 6. DESCRIPTION OF AMRAW-B COMPUTER CODE

CHAPTER 5

GENERIC DESCRIPTION OF AMRAW-B MODEL

The Radioactive Waste Management Systems Model (Fig. 5-1) has several parallel paths, each representing a phase in the waste management sequence: residuals treatment (interim surface storage and solidification at a reprocessing plant site), waste transport, repository operations, and terminal storage. If other phases become applicable, such as interim surface storage away from a reprocessing plant site, interim storage as spent fuel, reprocessing of waste form, and other transportation steps, each of these simply becomes an additional parallel path (branch) in the model. A more detailed diagram for one branch of the systems model is shown in Fig. 5-2.

Implementation of the model is by the AMRAW computer code (Assessment Method for Radioactive Waste Management). The code runs calculations separately for each branch of the model. Most of the current effort is applied to the terminal storage (disposal) branch (see Vol. II, Part 1). A preliminary demonstration of application to the repository operations branch is included in Part 2 of Vol. II. AMRAW is divided into two parts which are run separately: 1) AMRAW-A, Figs. 5-1 and 5-2, begins with the inventory at risk and calculates population dose rates, and 2) AMRAW-B, the Economic Model, uses the calculated population dose rates, applies incidence rates of health effects associated with radiation dose and calculates the economic costs of health effects in the population. AMRAW-B is described in this volume and AMRAW-A is described in Vol. I.

Discussion of the Economic Model uses the term "risk" as customarily used in economics, defined as the chance of damage or loss. Elsewhere in this study, risk is as previously defined: product of annual probability of occurrence of an event and the consequences of an occurrence.

This chapter discusses the two components of the Economic Model which comprises AMRAW-B: 1) health effects and their incidence rates, and 2) economic analysis for damage calculations associated with calculated health effects. Chapter 6 describes the AMRAW-B computer code.

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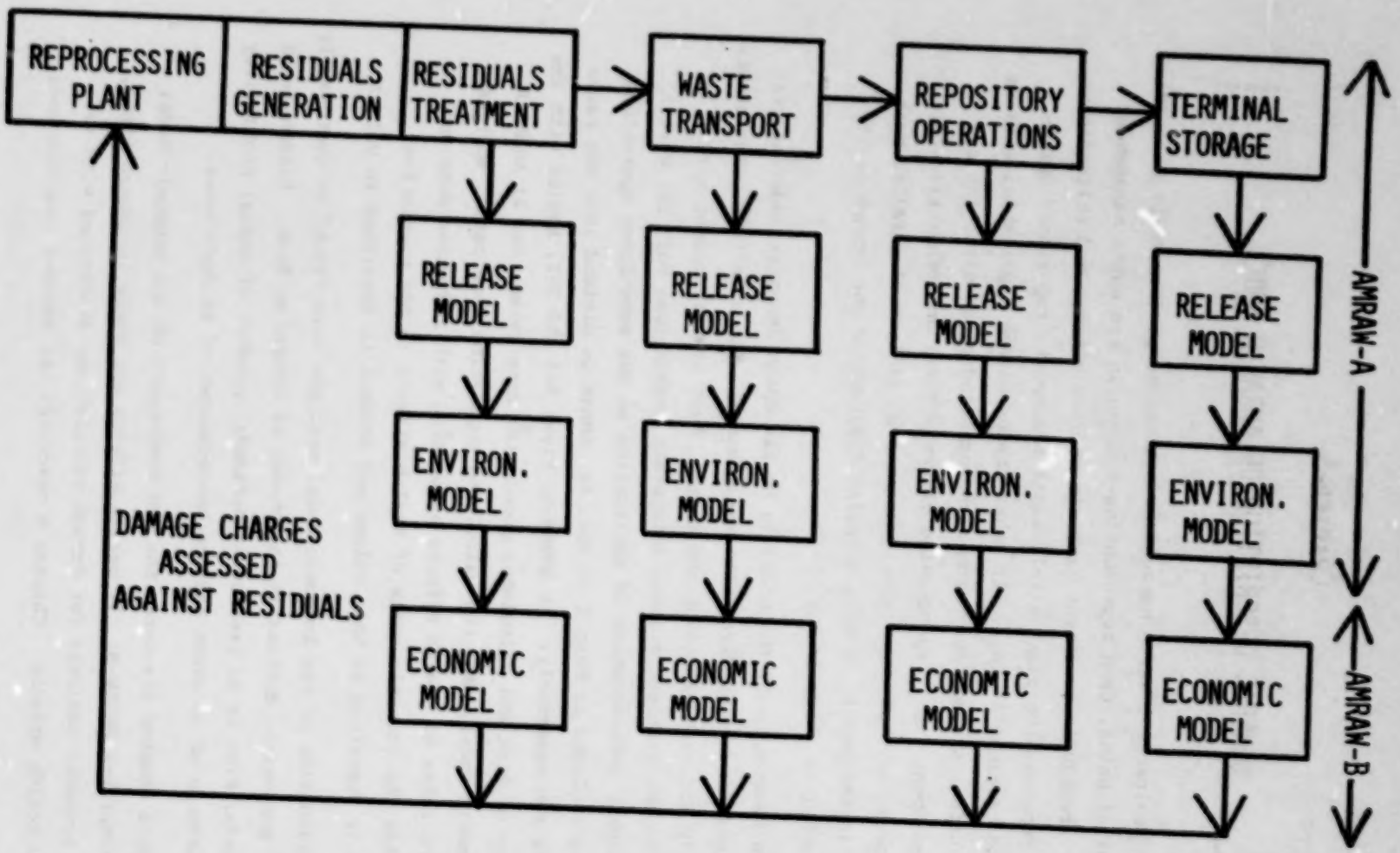

Figure 5-1. Radioactive waste management systems model.

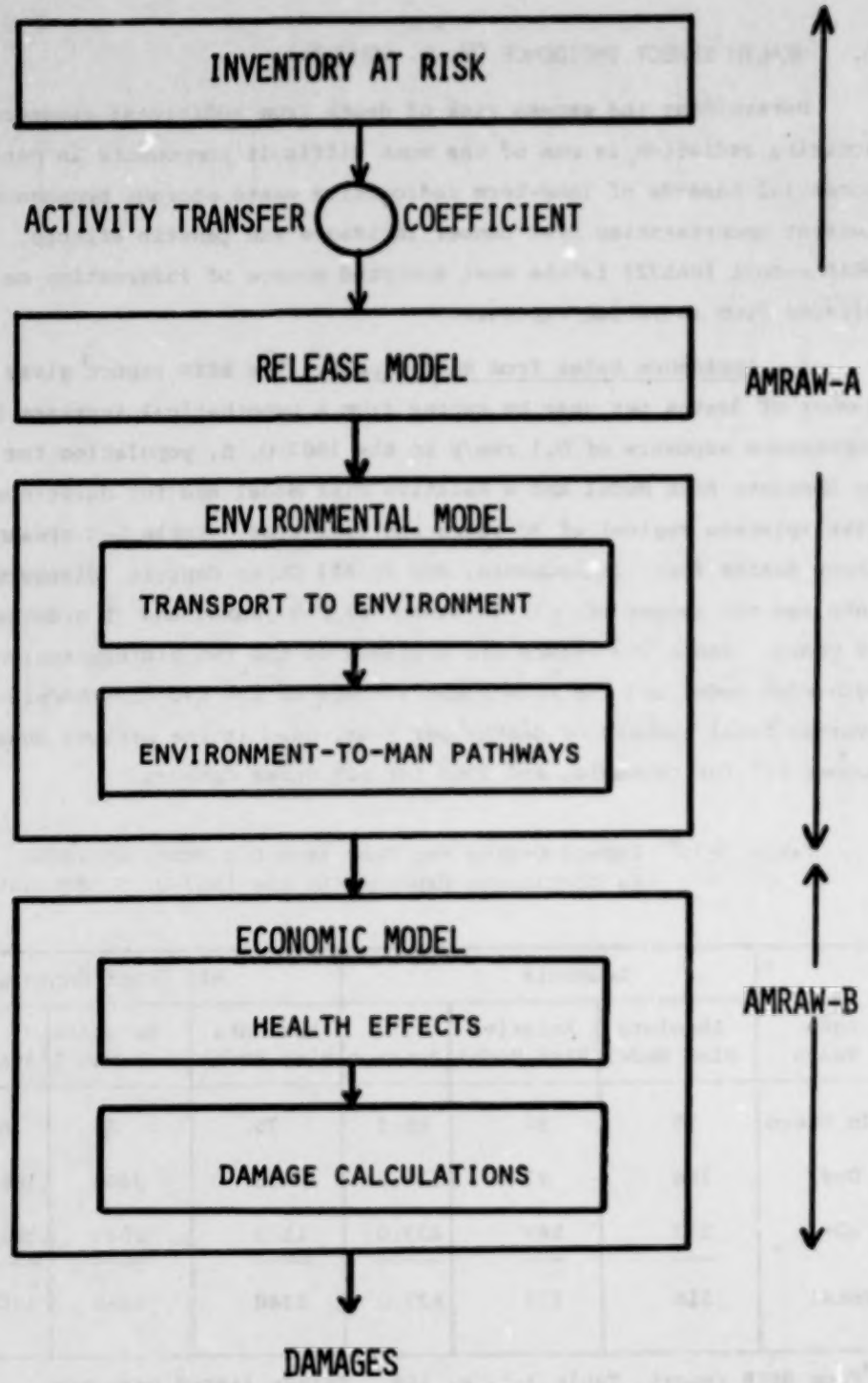

Figure 5-2. One branch of systems model.

A. HEALTH EFFECT INCIDENCE (W. D. SCHULZE)

Determining the excess risk of death from additional exposure to ionizing radiation is one of the most difficult components in estimating potential hazards of long-term radioactive waste storage because of the current uncertainties over cancer incidence and genetic effects. The BEIR report [NAS72] is the most accepted source of information on health effects from radiation exposure.

1. Incidence Rates from BEIR Report. The BEIR report gives the number of deaths per year by cancer from a hypothetical increase in continuous exposure of 0.1 rem/y to the 1967 U. S. population for both an Absolute Risk Model and a Relative Risk Model and for durations of risk (plateau region) of 30 years and life-time. Table 5-1 presents these deaths for: 1) Leukemia, and 2) All Other Cancers, disaggregated into age set ranges of: 1) in utero, 2) 0-9 years, and 3) greater than 10 years. Table 5-1 values are averages of the two plateau regions for each risk model and the subsequent average of the two risk models. The average total numbers of deaths per year, used in the present analysis, become 627 for Leukemia, and 3368 for All Other Cancers.

Table 5-1.[a] Excess Deaths Per Year from 0.1 Rem/y Increase in Continuous Exposure to the 1967 U. S. Population

Age, Years	Leukemia			All Other Cancers		
	Absolute Risk Model	Relative Risk Model	Average	Absolute Risk Model	Relative Risk Model	Average
In Utero	75	56	65.5	75	56	65.5
0-9	164	93	128.5	98	3292	1695.0
10+	277	589	433.0	1175	2040	1607.5
Total	516	738	627.0	1348	5388	3368.0

[a]From BEIR report, Table 3-1, p. 169. Values listed here are averages for 30 year and lifetime plateau regions.

Table 5-2 presents a further breakdown for excess deaths from radiation exposure by site for the All Other Cancers category from Table 5-1. The percentage shares used in allocating the All Other Cancers excess deaths into sites are also taken from the BEIR report. As mentioned in footnote b, the percentage breakdown for the over-ten age group is assumed to be valid for all groups. Additionally, the death rate due to breast cancer has been adjusted to include males. All numbers are again in terms of exposure for the 1967 United States population.

Table 5-2.[a] Breakdown of All Other Cancers By Site

Site	% of all other cancer by site for age groups 10+	Excess deaths per year from a hypothetical 0.1 rem/y increase in continuous exposure to the 1967 U. S. population by site[b]
G.I. including stomach	20	674
Lung	26	876
Bone	4	134
Breast	30	1010[c]
Remaining other cancers except leukemia	20	674
Total	100	3368

[a]From BEIR Tables 3-1, p. 169 and 3-2, p. 171.

[b]Assumes % breakdown for ages 10+ applicable for all ages. Thus, excess deaths = $\frac{\%}{100}$ x 3368.

[c]Adjusted to include males in the population.

Calculation of the excess deaths associated with genetic damage encounters greater uncertainty than for cancer calculations. The BEIR report [NAS72] discusses genetic risk in terms of ill health and does

not state a relationship between genetic damage and excess deaths. The report uses a range of 20 to 200 rem for the mutation rate doubling dose. Using these values, it is estimated that an exposure of 5 rem per generation would increase the equilibrium ill-health incidence by 0.5 to 5 percent of the present value (BEIR report, p. 56-57; see also p. 2).

For this study, the incidence rate for serious genetic effects may be obtained using data from the BEIR report (Table 4, p. 57) for the estimated effect of 5 rems per generation on a population of one million live births. The total for: 1) dominant diseases, 2) chromosomal and recessive diseases, and 3) congenital anomalies, anomalies expressed later, and constitutional and degenerative diseases, is listed as 60-1000 during the first generation, and 300-7500 at equilibrium. The equilibrium value becomes 60-1500 effects per 10^6 person rem. The log mean value for this range is 300. An adjustment is needed to determine the genetic effect incidence rate for dose to the population as a whole. The BEIR table assumes that the mean age at reproduction in 30 years. However, considering the fraction of the population who become parents, the U. S. population is reproduced every 50 years instead of 30 years. The equilibrium incidence rate for the U. S. population then becomes $0.6 \times 300 = 180$ per 10^6 person rem. Rounding off, the value of 200 is obtained, as is being used by the EPA. The corresponding number of serious genetic effects in the U. S. population for a 0.1 rem/y continuous exposure rate becomes $200 \times 197.7 \times 0.1 = 3954$ effects/y.

Combining Tables 5-1 and 5-2 and the genetic risk calculation, the excess deaths due to 0.1 rem of exposure for the eight categories under consideration can be summarized, as shown in Table 5-3. The increased risk of death for 0.1 rem exposure for 10^6 population is also presented in Table 5-3. By dividing the excess deaths of each category or site by the 1967 U. S. population in millions, the increased deaths per million population is obtained. Thus the value of 3.2 in column 3 is the increased deaths per year per 1,000,000 population from leukemia for a 0.1 rem/y increase in continuous exposure. The total per 10^6 population per 0.1 rem is 40.2. However, no account is taken in this table of length of time necessary for genetic effects to reach equilibrium from the hypothetical exposure.

Table 5-3. Excess Deaths Per Year from a Hypothetical 0.1 Rem/y Increase in Continuous Exposure to the 1967 U. S. Population, By Site or Category

Site or category	Excess deaths per year	Increased deaths per year per 0.1 rem/y increase in continuous exposure per 10^6 population[a]
Leukemia	627	3.2
All Other Cancers:		
G.I. including stomach	674	3.4
Lung	876	4.4
Bone	134	0.7
Breast	1010	5.1
Remaining cancers	674	3.4
Sub-total	3995	20.2
Genetic[b]	3950	20.0
Total	7945	40.2

[a]Increased Risk of Death - Excess Deaths/1967 U. S. population in 10^6; 1967 U. S. population - 197.7112×10^6.

[b]Assumes serious genetic effect is equivalent to a death for damage evaluation purposes.

It should be clear from the discussion above that the BEIR analysis implicitly assumes a linear dose-response relationship, as shown by Curve A in Fig. 5-3. Curve B illustrates a "threshold" effect, intercepting the horizontal axis.

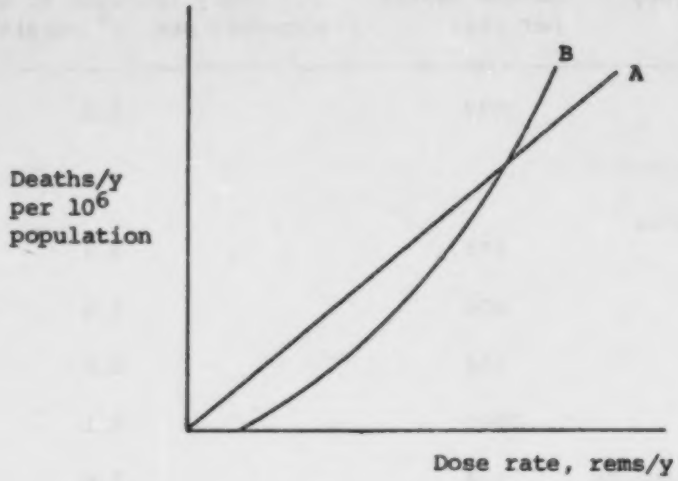

Figure 5-3. Death rate - dose rate relationship.

The cumulative linear dose response is the more accepted relationship for carcinogenesis in general and the effects of ionizing radiation in particular. However, conflicting evidence exists and the response relationship may be quite complex both in terms of the intensity and spacing of doses.

2. Calculation Methodology. The methodology for calculating excess cancer deaths using the BEIR results described in Table 5-3 can be illustrated using the following formulation:

$$N_k \begin{bmatrix} M_{1,1,k} & \cdots & M_{1,7,k} \\ \vdots & \ddots & \vdots \\ M_{25,1,k} & \cdots & M_{25,7,k} \end{bmatrix} \begin{bmatrix} D_1 \\ \vdots \\ D_7 \end{bmatrix} = \begin{bmatrix} TD_{1,k} \\ \vdots \\ TD_{25,k} \end{bmatrix} \qquad (5\text{-}1)$$

(25 x 7) (7 x 1)

where

M_k = a matrix of doses, M(i, j, k) for the kth zone in millirems per person in the tth time period, for the ith nuclide, impacting the jth organ,

(i = 1,. . . . 25) (j = 1, . . . 7) (k = 1,. . . 8)

D = a vector of increased deaths per 0.1 rem per 10^6 population

N_k = population in the kth zone in time period t,

TD_k = a vector, TD(i, k), representing deaths associated with the dose from each nuclide in the kth zone in time t.

The matrix M_k is an input into the AMRAW-B economic code from the AMRAW-A code. The vector D consists of values such as presented in Tables 5-3 exclusive of genetic risk adjusted to millirems. Equation 5-1 applies for deaths by nuclides in the kth zone for the tth time period.

Thus, population in the kth zone (a scalar), N_k, times the dose matrix, M_k (by nuclide by site) times the incidence vector, D, gives total deaths for Zone k (by nuclide), TD_k. Deaths are summed over all the geographic zones in the study region to obtain a total for a particular time period by nuclide.

A similar product of matrices applies to genetic risk. The treatment of the genetic calculations and the extension of both genetic and cancer health effects into evaluations in terms of economic units is described in Section B. which follows. Preceding this extension, Section B. first discusses concepts of present value of future damage, and the value of risk to life.

B. ECONOMIC ANALYSIS (W. D. SCHULZE)

This section first discusses the concept of present value of future damages, then presents the background theoretical development of the economics of risk, and finally describes the calculation of present value of statistical deaths from health effects. The latter is based upon an estimate of the compensation required to induce a group of high risk individuals to accept a small increase in risk.

1. Present Value of Future Damages. Valuing future damages in current dollars can be best explained by demonstrating how benefit cost analysis has traditionally considered risk of catastrophe over time in the case of large hydroelectric projects. As a decision criterion, for a hydroelectric project to be constructed, benefits including the value of electricity generated and recreation must exceed all costs which include cost of construction, costs of operation and potential expected damages which might occur if the dam were to fail. Given that in each year over, for example, an expected 100-year lifetime there is a certain probable or expected damage from failure of the dam, the cost to be considered in present terms is the amount of money which must be invested now to cover expected future damages. Thus, if in the 50th year of the dam's life probable damages are $100,000, the cost in year 0 to provide that money with a 5% interest rate is $8,208.50 since $8,208.50 reinvested continuously for 50 years in a bank with 5% compound interest will grow to $100,000. Thus, the cost in economic terms of a $100,000 damage 50 years hence is $8,208.50, given that a bank exists which pays a 5% rate of return over that interval. In reality, all that this requires is that the dam insure itself against potential future losses.

In this study, consideration is given to use of discounted present values of future environmental damages from a long-term nuclear waste repository to give a current equivalent damage cost for benefit cost analysis. However, while it is plausible to assume that banking and insurance institutions will exist to make this discounting procedure plausible over the life of a dam, such an assumption becomes doubtful for the time period of 1,000,000 years of concern for a nuclear waste repository. In other words, benefit cost analysis requires that enough

money be invested now to cover future potential damages, and that this money be made available to potential future individuals who may be damaged, for reasons of equity. The long time periods involved in nuclear waste storage must bring this whole procedure into serious question on grounds that the necessary institutional mechanisms may not exist over the required interval to justify discounting. If these mechanisms do not exist, then a zero rate of discount is the most tenable assumption for economic analysis and will provide an upper-bound estimate of these costs. Further, the traditional time value of money concept does not appear to hold for evaluating future health effect damage costs over a time frame of thousands of years. Thus, while this study provides no answer to this dilemma, the analysis method used here provides for use of any appropriate discount rate. The 0% discount rate cases presented in this analysis give the simple total of dollar damages over the first 1,000,000 years of life of the repository as best as can be calculated. Positive interest rate cases give as damages the amounts that would have to be invested now to provide with continuous compounding adequate compensation for future expected damages to future generations assuming such institutions will remain in existence.[a]

Another major methodological problem addressed at length in this section is the problem of valuing in money terms risk of death. Fortunately, recent theoretical and empirical research has given improved estimates which do not claim to measure the value of life, but rather attempt to measure the economic cost to individuals for accepting a small increase in risk of death.

2. The Economics of Risk. Prior to the appearance of the theoretical development and empirical investigation of Thaler and Rosen [T175], it was a common practice to view the value of an individual's life as

[a]Another methodology which might be employed on equity grounds would be to invest enough money now such that the expected value of the investment after 1,000 years, including the probability that the bank still exists, equals expected damages in the year 1,000 from the nuclear waste repository! For example, if damages are \$100,000 after 1,000 years, we need to invest $\$1.93 \times 10^{-17}$ today at a 5% interest rate to cover that future loss. But, if the probability of the account remaining is 10^{-20}, then we must invest $\$1.93 \times 10^{3}$ today to expect to have the money for damage payments available in 1,000 years. That these calculations seem bizarre underlines the difficulties.

the sum of the present value of his or her future earnings [Ri66]. Many researchers have employed such measures to approximate the dollar value of environmental damages to human health [La72].

However, it is clear that the sum of the present value of the future earnings is not a correct measure of the value of life. Acceptance of such measures implies that the value of life is itself a measurable quantity (a point in doubt) and that the value of life for the aged, children, the unemployed, and the housewife is very much lower than the employed head of a household. Obviously, such an implication is erroneous since many employed heads of households place as much if not more value on risks to life of their dependents and parents as on their own.

In economic terms, the present value of future earnings corresponds to the equivalent variation concept (E.V.), which measures the amount of money a person is willing to give up in order to prevent the situation in which probability of death is increased. This dollar amount is related to his wealth. As an example, in a robbery, a rational individual will part with all his available wealth to save his life.

Another economic measure is compensating variation (C.V.) which can be employed to develop a theoretical concept for valuing life but demonstrates the "unmeasurability" problem noted above. In theory, the C.V. concept measures the compensation required to induce an individual to accept a situation where the probability of death is increased (note then that C.V. is a voluntary measure). When the probability of death approaches unity, the C.V. measure can be taken as an estimate of the value an individual places on his life. Clearly, the value of life measured through C.V. must be infinite since the worth of any offered compensation approaches zero as the probability of death approaches unity. This occurs because the probability of enjoying the compensation for increased risk goes to zero as the probability of death approaches one.

Therefore, E.V. does not provide a proper estimate of the value of life since coercion must be involved and the value of life cannot be estimated through C.V. since infinity is not "measurable." However, C.V. may be used if the compensation necessary to induce an individual to accept a situation where the probability of death is increased slightly

is of interest. The C.V. thus estimated corresponds to the value of increased risk of death (for small increases in risk), not the value of life. Also the measure assumes individuals are voluntarily induced to accept such risks.

To examine the behavior of individuals with respect to risk, consider the classic example of Robinson Crusoe on an isolated island. Assume he derives utility from consuming coconuts which he picks from a tree. This of course assumes Crusoe landed on an island where coconuts grow. The number of coconuts at his disposal depends on the amount of risk he is willing to undertake in the coconut picking activity. It is assumed that picking coconuts is a dangerous endeavor, a realistic assumption since he may fall down and possibly die from a broken neck or other injuries. Therefore, the number of coconuts picked by Crusoe per period of time is a function of the level of risk associated with picking coconuts, and the more rapidly he works the greater the risk in the production of coconuts.

Let W denote the number of coconuts picked by Crusoe or the amount of wage earned by a typical employee. Define u(W) as the utility function of Crusoe or a typical individual with

$$\frac{du}{dW} > 0.$$

Let ¶ denote the probability of getting killed on the job, and G(¶) as the production function for coconuts with dG/d¶ > 0. The gradient dG/d¶ is positive since a given labor input will produce more output as the level of risk associated with production process increases. It is seen that the number of coconuts at Crusoe's disposal is given by

$$G(¶) = W.$$

As a rational individual, Crusoe would attempt to maximize the expected utility of consuming coconuts subject to the constraint that governs his coconut production, thus

$$\max\ (1 - ¶)\ u(W)$$
$$\text{subject to} \quad G(¶) - W = 0.$$

The necessary conditions that ensure the maximization of his expected utility can be obtained by forming the Lagrange function and setting its derivatives with respect to the relevant arguments equal to zero.

$$L = (1 - \P)\, u(W) + \lambda\Big(G(\P) - W\Big) \tag{5-2}$$

$$\frac{\delta L}{\delta \P} = -u(W) + \lambda G_{\P} = 0. \tag{5-3}$$

$$\frac{\delta L}{\delta W} = (1 - \P)\, u_W - \lambda = 0. \tag{5-4}$$

Dividing Eq. 5-3 by Eq. 5-4 yields

$$\frac{u(W)}{(1 - \P)u_W} = G_{\P}$$

which gives Crusoe's "optimum" choice of ¶ and W given the constraint defined above on production.

To consider a more realistic situation, consumers and producers must be separated and their behavior with respect to risk must be examined. To examine the behavior of individuals, with respect to risk, consider an individual who has the option of choosing between a risk-free job that pays an annual earning of W* and a high risk job that has a probability of getting killed while at work of ¶ and pays an annual earning of W. A rational individual would accept the high-risk job if the expected utility of the earnings from it was equal to the utility of earnings from the risk-free job. In other words, he would accept the high-risk job if

$$(1 - \P)u(W) = u(W^*). \tag{5-6}$$

Note that W* is a constant, while W must be an increasing function of ¶ as shown in Eq. 5-8. Differentiating Eq. 5-6 yields

$$(1 - \P)u_W dW - u(W)\, d\P = 0 \tag{5-7}$$

$$\frac{dW}{d\P} = \frac{u(W)}{(1 - \P)u_W} > 0. \tag{5-8}$$

Inequality (Eq. 5-8) describes the individual's behavior towards high-risk jobs. In other words, a higher wage is required to accept a higher risk job so the wage level is a function of risk, W(¶).

To examine the behavior of producers with respect to risk, consider a typical producer whose output is an increasing function of the probability or risk of death (¶) associated with his production process. His labor payment is an increasing function of the associated risk of being killed or injured on the job. His profit function, PR, can be expressed as

$$PR = P \cdot G(¶) - W(¶) \tag{5-9}$$

where

P = price of final output,

G(¶) = the production function with $\frac{dG}{d¶} > 0$, and

W(¶) = labor payment with $dW/d¶ > 0$.

The profit maximization behavior with respect to risk requires that

$$\frac{\delta PR}{\delta ¶} = 0$$

or

$$P \cdot G_¶ - W_¶ = 0.$$

In perfect competition, the producer accepts price of his product; therefore, P = 1 can be assumed consistent with coconuts as a measure of value, which yields

$$\frac{dG}{d¶} = \frac{dW}{d¶} . \tag{5-10}$$

That is, production is expanded until the absolute value of marginal revenue equals marginal cost with respect to risk, which is the familiar profit maximization behavior of the firms.

Equation 5-5 is identical with the combined conditions of 5-8 and 5-10 which demonstrates that where a market for risk of death exists the

effect of risk is incorporated in the job-seeking behavior of individuals and firms in an optimal way.

The existence of such a market is verified by observing that work-related probabilities of death and injury vary from one job classification to another, and that compensating differences in wage rates among various job classifications exist. When this market is in equilibrium, the revealed difference between the wages of high risk and less risky jobs corresponds to the value of increased risk of death. The empirical work of Thaler and Rosen [T&75] attempts to estimate such wage differences resulting from risk variation. The methodology employed by Thaler and Rosen and the results of that investigation are briefly discussed below.

To relate the work of Thaler and Rosen to the simplified theoretical discussion above, the graphical analysis in Fig. 5-4 will be used. Hence G and W again denote Robinson Crusoe's production opportunities and preferences over risk, ¶, respectively. Note that the wage in coconuts required by Crusoe to accept risk ¶ increases at an increasing rate and becomes vertically asymptotic to the right as ¶ → 1. This implies that to induce him to accept a risk greater than ¶* which he chooses voluntarily given his production possibilities, G(¶), requires a bribe or compensation equal to the vertical distance

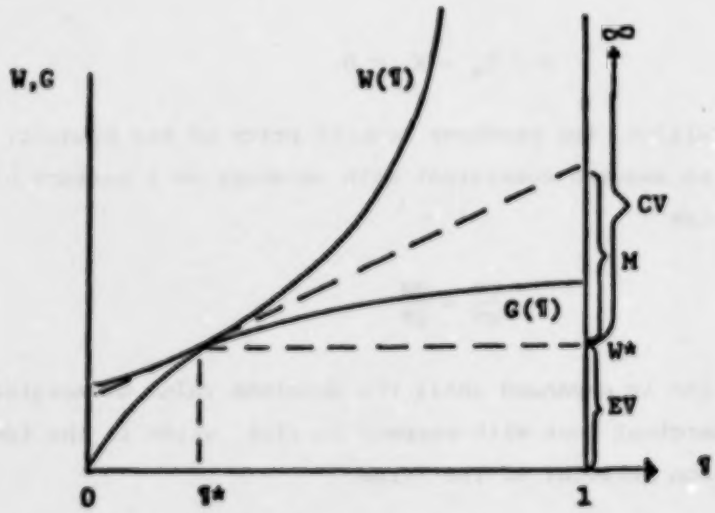

Figure 5-4 . Opportunity versus risk.

from the dotted horizontal line denoted W* to the W(¶) curve. Clearly, this compensating variation measure goes to infinity (CV in Fig. 5-2) as ¶ → 1 since the W(¶) function is asymptotic (note from Eq. 5-8 that dW/d¶ → ∞ as ¶ → 1).

Alternatively, Crusoe only has W* coconuts available to give to a thief who threatens his life so this gives the E.V. measure in Fig. 5-4.

What Thaler and Rosen have estimated is a market measure of risk (denoted M in Fig. 5-4). In other words, given decisions such as Crusoe's to choose risk level ¶*, they have determined dW/d¶ in that neighborhood. One can then extrapolate using the dotted lines as shown in the figure to get a market measure of the value of risk of death between the chosen level, ¶*, and 1. This value shown as M clearly does not measure the value of life in a particular situation as do the CV and EV measures but rather relates to the dollar value of a small increase in risk around ¶*. In other words the extrapolation is invalid and does not measure the value of life. However, the estimate of dW/d¶ is valid for measuring the dollar value of a small change in risk for individuals who choose occupations with risk ¶*.

Thus, to estimate wage earnings as a function of the associated risk, Thaler and Rosen consider the existence of a job market for safety with the implication that job-associated risk and corresponding levels of wage rates are positively related. The component of the value of risk of death expressly under consideration is realistically assumed to be the demand price for a person's own safety. By answering the question, "What wage incentive is required to induce persons to accept an increase in the probability of his own death by a 'small' amount?", such estimates are obtained.

In order to simplify the analysis and avoid certain econometric problems, a market of homogeneous workers is considered on the demand side. Attitudes toward death and injury risk are assumed to be independent of exogeneously acquired skills. Differences between jobs then arise only through the associated amount of death and injury risk. These assumptions imply that for a particular job the identity of a particular employee or employer is irrelevant. A perfect insurance market is assumed where the cost of insurance equals its actuarial value.

Additionally, workers and insurance companies know the true probability of injury associated with a job and there exists no moral hazard. This last assumption is important in reaching an equilibrium in the market.

Equilibrium in the job market for safety under the above assumptions can be characterized by a function W(¶) as we have shown where ¶ denotes the probability of death. Thus, there is a wage rate associated with each value of ¶. In an equilibrium situation, each worker will choose an optimal value of ¶ by comparing psychic costs of increased risk with monetary returns in the form of lower wages, the risk associated with a job is decided upon by the firm. When the market is cleared an equilibrium situation will exist.

The econometric model developed by Thaler and Rosen regresses wage earnings of individuals on job risks they encounter and their personal and job-related characteristics. Using Ordinary Least Squares (OLS), the regressions found in Table 5-4 were used where the independent variable is the weekly wage rate. The risk variable was scaled by 10^{5} and thus the estimated risk coefficient, .0325, in Table 5-4, column 1, implies that jobs with extra risks of .001 pay $3.52 per week more than jobs with no risk, or $176 per year. Noting that the slope of the wage risk equation W'(¶) estimates the implicit supply and demand price to high risk jobs, the following interpretation [T&75] is appropriate:

> Suppose 1,000 men are employed on a job entailing an extra death risk of .001 per year. Then on average one man out of 1,000 will die during the year. The regression indicates each man would be willing to work for $176 per year less if the extra death probability were reduced from .001 to 0.0. Hence they would together pay $176,000. Furthermore, it must also be true that those firms actually offering jobs involving .001 extra death probabilities must have to spend more than $176,000 to reduce the death probability to zero, because there is a clear cut gain from risk reduction if costs were less than that amount.

If social economic status rather than occupational dummies were used in the linear regression the estimate of the risk coefficient becomes .0520 as shown in Eq. 2 of Table 5-4. Using the analysis shown above in this case gives a value of $260 for a decrease in risk of 10^{-3}.

The important point to be remembered from this brief summary of Thaler and Rosen's work is that the value of risk of death derived is

Table 5-4. Regression Estimates of W(¶, c) - Linear Form (Standard Errors in Parentheses)

Independent Variables	Eq. 1 of Ref.[a]	Eq. 2 of Ref.
Risk	.0352 (.0210)	.0520 (.0219)
Urban	13.50 (4.2)	15.71 (2.95)
Northeast	-3.71 (3.65)	-4.29 (3.67)
South	-8.86 (3.70)	-8.90 (3.74)
West	9.13 (4.13)	10.30 (4.18)
Age	3.89 (0.80)	3.81 (0.83)
$(Age)^2$	-.0479 (.0092)	-.0463 (.0097)
Education	3.40 (0.55)	3.27 (2.40)
$(Education)^2$	-	-.021 (.128)
White	22.92 (4.53)	22.93 (4.50)
Union	25.5 (3.25)	27.16 (3.23)
Full-time	-1.63 (12.9)	-.56 (12.6)
Hours Worked	1.50 (.12)	1.41 (.12)
Occ 1 Operative	-18.7 (9.2)	-
Occ 2 Service Worker	-24.6 (9.5)	-
Occ 3 Laborer	-25.0 (13.4)	-
SES 1	-	4.68 (5.17)
SES 2	-	-17.17 (3.34)
SES 3	-	-20.69 (5.53)
R^2	.41	.41
No. Observations	907	907
Sample	All	All

[a]SOURCE: R. Thaler and S. Rosen, "Value of Saving a Life: Evidence from the Labor Market," manuscript 1975, p. 34, [T&75].

not a measure of the value of life but of risk of death appropriate for small changes in that risk. Thus, the required compensation that is estimated corresponds to what must be paid in order for individuals to incur increased risk and is an estimate of the value of increased risk of death based on observed behavior rather than on assumptions about lost earnings from death. Furthermore, unlike lost earnings analysis which implies that the value of life is less for women, the aged, children and other groups, a risk valuation may well imply the opposite since society usually attempts to reduce risk for women and children below that experienced by male heads of households. This suggests that Thaler and Rosen's work may underestimate the value of risk of death as does the fact that their data base includes an exceptionally high-risk set of job classifications which may attract fewer risk-averse individuals.

This latter problem is shown graphically in Fig. 5-5. The two heavy lines, S_1 and S_2, represent the overall market relationship between wages and risk, the former for less skilled labor and the second for skilled, highly educated labor. S_1 and S_2 will exist if there are a continuum of jobs available at different market determined risk levels.

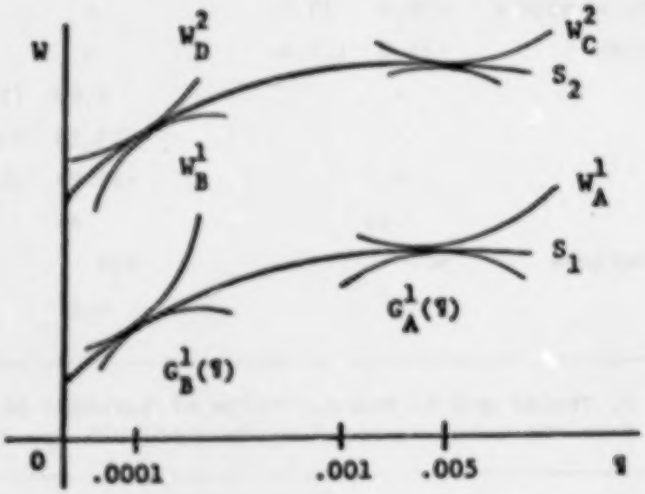

Figure 5-5. Market relationship and variation in risk aversion.

To show why Thaler and Rosen underestimate the value of risk consider Mr. A's wage-risk relationship or indifference curve W_A^1 (¶). Let us assume that Mr. A is a lumberjack and has an annual risk of job related death of .005. Clearly from his preferences he is not risk averse and chooses high risk and high wages given his productive opportunities as a lumberjack shown by the concave curve below W_A^1 and S_1 denoted G_A^1. Compare this situation to that of Mr. B, a shoe salesman of similar educational and skill background, who, however, is quite risk averse as shown by his preferences W_B^1 (¶) and chooses a much lower level of risk given his productive opportunities, G_B^1 (¶). Shoe salesmen may of course fall off their ladders (if in a hurry), so risk again affects productivity. The point here is that Thaler and Rosen have examined risky job classifications with a mean death probability of .001 with some observations ranging up to .005 which is extraordinary rather than typical. Clearly the shoe salesman has a higher dW/d¶ than the lumberjack and Thaler and Rosen have given a lower bound estimate of this relationship compared to the more risk averse general population. The same argument holds for the higher skill level S_2 where W_D^2 as those for a college professor of aerodynamics. Clearly the shoe salesman and the professor will require greater compensation for increased risk than the lumberjack and the test pilot. Unfortunately, Thaler and Rosen have given an estimate of the latter value.

In summary, Thaler and Rosen have provided an estimate of the necessary compensation required to induce a group of high risk individuals (those who choose jobs with a mean risk of death of .001) to accept an additional increase in risk of 10^{-3} per year which ranges from $176 to $260 per year. This estimate is not valid for other groups in our society who are likely more risk averse and would require greater compensation to accept the same increase in risk. These numbers do, however, provide the first available lower bound estimates for this value.

3. Cost of Risk to Health from Potential Repository Releases. As discussed previously, Thaler and Rosen [Tℓ75] have derived an estimate of the dollar value of risk of death appropriate for small increases in that risk. Using the value of $260 per year associated with an increase in risk of 10^{-3} per year, a lower bound estimate of the cost of excess

risk of death can be calculated.

Calculated dose rates to specific sites obtained in AMRAW-A may be related to health effects in accordance with incidence rates obtained from the BEIR report [NAS72]. Table 5-5 lists the sites for which dose rates are calculated in AMRAW-A and the corresponding health effects covered by the BEIR report, from Table 5-3. A direct match is obtained for some organ sites, such as for lungs, but breast and other cancers use total body dose rates as an approximation. The last column in Table 5-5 lists the net incidence rates of health effects for each of the dose rate categories calculated in AMRAW-A; these are input to AMRAW-B.

The corresponding implied cost per man-rem to each site is listed in Table 5-6. The values indicated are based upon $260,000 per statistical death, derived in the previous section. The totals given in Table 5-6 are of reference interest but should be used with caution, as addition is not strictly correct. For a given exposure situation, the dose is not the same for each site and total body. In Table 5-6, total body is an approximate representation for sites not specifically calculated; the indicated totals are a rough approximation accounting for all sites.

As stated earlier, a zero rate of discount is assumed for the economic analysis results obtained for this study. In the event that a non-zero discount rate becomes justified, such as might be the case if a cancer cure is projected, AMRAW-B includes a discount rate in calculations.

(a) Cancer Risk. Given expected deaths as determined in Eq. 5-1 of Section 5.A. over the several cancer categories, the discounted present value of total cancer risk over a one-million-year period is

$$\int_{o}^{10^6} e^{-rt} \left[\sum_{i=1}^{25} \sum_{k=1}^{8} TD_{ik}(t) \times \$2.60 \times 10^3 \right] dt \qquad (5\text{-}11)$$

where the term in brackets is the current annual damage summed over nuclides i (25 assumed) and zones k (8 assumed) using expected total deaths per time interval TD_{ik} as derived in Section 5.A. and Thaler and Rosen's value of $260/year for an increase in risk of 10^{-3}. For a zero discount rate, r = 0, and Eq. 5-11 reduces to

Table 5.5. Health Effect Incidence Rates

AMRAW-A Dose Rate Site	BEIR Report Health Effect	Deaths/ 10^6 man-rem	AMRAW-B Input, Deaths/ 10^6 man-rem
Total body	Breast cancer[a] Remaining cancers[b]	51 34	85
GI Tract	GI Tract cancer (including stomach)	34	34
Gonads	Genetic effects	200[c]	200
Liver	____ [b]	___[b]	0
Lung	Lung cancer	44	44
Bone marrow	Leukemia	32	32
Bone	Bone cancer	7	7
Thyroid	____[b]	___[b]	0

[a]Dose rates to breast approximated by total body rates.

[b]Remaining cancers include liver and thyroid cancer.

[c]Serious genetic effect assumed equivalent to a death for damage evaluation purposes.

Table 5-6. Man-rem Values by Site

Site	Deaths/ 10^6 man-rem	$/man-rem[a]
Total body	85	22.10
GI Tract	34	8.84
Gonads	200	52.00
Liver	0	0
Lung	44	11.44
Bone marrow	32	8.32
Bone	7	1.82
Thyroid	0	0
TOTAL[b]	402	104.52

[a] $/man-rem = (deaths/$10^6$ man-rem)($260,000/$10^6$).

[b] Total is of reference use only.

$$\int_{o}^{10^6} \left[\sum_{i=1}^{25} \sum_{k=1}^{8} TD_{ik}(t) \times \$2.60 \times 10^3 \right] dt. \qquad (5\text{-}12)$$

(b) Genetic Risk. The categories of cancer mortality by site accrue in one generation. Genetic risk presents a special problem in that the equilibrium level of genetic damage according to the BEIR report [NAS72] might not be reached until 900 y after an increase in the continuous exposure level. In this analysis, it is assumed that a serious genetic effect may be equated to a death for damage evaluation purposes. Present programming in AMRAW-B handles genetic effects in the same manner as cancers, as in Eq. 5-12. The equilibrium incidence of genetic effects (200 per 10^6 man-rem from Table 5-5) conservatively accrues to the time increment in which dose is calculated. If a non-zero discount rate becomes justified, it may be appropriate to add provisions which account for deferring of genetic effects. This is discussed in detail in Appendix A.

CHAPTER 6

DESCRIPTION OF AMRAW-B COMPUTER CODE

The AMRAW Code is written in Fortran IV language. The two parts of the code are: 1) AMRAW-A which contains the Source Term, the Release Model, and the Environmental Model, and 2) AMRAW-B which contains the Economics Model. They are being run separately but may be joined if desired. There is an advantage to running the first part independently to determine sensitivity of environmental concentrations and dose rates to variations in input. Similarly, there is an advantage to running the economic model independently to study the response to varied economic parameters. User's manuals are Volume IV for AMRAW-A and Volume VI for AMRAW-B. This chapter provides a brief description of AMRAW-B.

The flow of AMRAW-B calculations is best described first using the sequence indicated by Fig. 5-2: 1) determine rate of occurrence of health effects, and 2) perform corresponding damage calculations in economic units. An altered sequence of the actual calculations within AMRAW-B is then described. The matrix of local dose rates from AMRAW-A, to individuals in each zone from each radionuclide to each body site (organ) during each time increment, multiplied by the population of each zone and then multiplied by the set of health effect incidence rates for each body site, obtains the health effect incidence rates in each zone. Similarly, nonspecific dose rates from AMRAW-A (dose to a nonspecific population) multiplied by health effect incidence rates obtains health effect incidence rates corresponding to nonspecific dose. As actually calculated within AMRAW-B, the input incidence rates of health effects, deaths/10^6 man-rem, are first converted to $/man-rem by multiplying by $260,000/$10^6$ (see Table 5-6). Damage rates, $/y, in each zone (and the nonspecific category), are calculated by multiplying together: dose rates, populations, and $/man-rem. The damage rates, $/y, are accumulated over nuclides and organs in each zone (and nonspecific) versus time. Total damage rates are also accumulated over zones, organs, and times for each nuclide. Damages during each time increment, $, are then obtained by multiplying rates by the length of each time increment and accumulated over the total time range. Finally, the number of deaths

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(health effects) during each time increment are obtained by dividing the damages in dollars by $260,000. Results are obtained for both high and low population projections.

The present dimensioning of AMRAW-B is as follows:

1) Radionuclides: 25.

2) Geographic Zones: 8 (the nonspecific category is treated as a ninth zone in calculations).

3) Human Organs: 8. Typically, one of these is total body.

4) Time Increments: 50.

Input data is furnished by three files:

1) AMB. This file provides economic model control and conversion data, including discount rate (zero presently used), cost assigned to a death, the numbers of times, zones, radionuclides, and organs involved, incidence rates of health effects by body site or organ, high and low population projections by zone, and designation of decay groups.

2) AM1E. This file provides values of time at the end of each time increment, names of each radionuclide, and the mass of each radionuclide (ingrams) in the repository inventory at each time.

3) ECON48 (number is case number). This is the large output matrix, MAN1, of dose rates from AMRAW-A, restructured for AMRAW-B input.

Radionuclide mass versus time is used within AMRAW-B at this time only for calculation of marginal damages ($/gram) by decay group, based upon the accumulated inventory at the time repository operations cease. The full nuclide matrix provides for possible additions to AMRAW-B for allocation of damages to elements in the waste. The dose rate matrix, MAN1, from AMRAW-A is arranged as shown in Table 6-1. With the present dimensioning used, the dose rates are presented in 225 separate tables (9 zones x 25 nuclides). For input to AMRAW-B, this is processed through an auxiliary program, COMPRESS, to strip away headings and the time column, producing a data file with 11,250 lines (from 225 tables x 50 lines each). Each line has dose rate values for 8 organs resulting in 90,000 data items.

Table 6-1. Arrangement of AMRAW-A Dose Rate Output: Local Dose Rate by Zone and Nonspecific Dose Rate

---

Zone 1[a]

Nuclide 1

Time Increment 1: Organ 1, Organ 2, ... Organ 8.[b]
2: Organ 1, Organ 2, ... Organ 8.
(repeat for other time increments)
⋮
50: Organ 1, Organ 2, ... Organ 8.

Nuclide 2
(repeat for other nuclides)
⋮
Nuclide 25

Zone 2
(repeat for other zones)
⋮
Zone 8

Nonspecific (handled as Zone 9).[c]

---

[a]Local dose rates are mrem/y.

[b]Organ refers to each body site for which dose rate is calculated.

[c]Nonspecific dose rates are man-rem/y.

Output from AMRAW-B is the series of tables listed in the directory in Table 6-2. Table 1 as numbered by AMRAW-B provides average damage rates in each zone, for nonspecific, and the total, versus time. Sub-tables are for high and low population projections, respectively. Table 2 is a series of tables, one for each time increment giving average damage rates: total for zones, nonspecific, and total by nuclide, for high and low population. Table 3 presents the total discounted present value of damages over the entire time range for each nuclide, sub-totals for each decay group and the overall total, for high and low populations. This table also includes marginal damages, by decay group and total, based upon masses in repository inventory at the beginning of the terminal storage phase. Table 4 presents total expected deaths per time interval in each zone, for nonspecific, and the total, versus time. Similarly, Table 5 presents total damages in dollars per time interval. Sub-tables of Tables 4 and 5 are for high and low populations.

AMRAW-B runs with 124 k bytes of core storage, 125 tracks (900 k bytes) of disk storage for input data, 10 cylinders (200 tracks or 1440 k bytes) of disk for intermediate storage, and requires 270 seconds of CPU time in the UNM IBM 360/67 computer. Input data can be furnished from tape if preferred.

Table 6-2. Directory of AMRAW-B Output Tables

Table No.	Title or Description	Nuclides	Units				Components				Population	
			$/y	$/Δt[a]	$/10^6 y	Deaths/Δt[a]	Each Zone	Total of zones	Non-specific	Total	High	Low
	Output listing of selected AMRAW-B input											
1-1	Zonal and Total Damages for High Population Projection, $/y.	Total	X				X	X	X	X	X	
1-2	Zonal and Total Damages for Low Population Projection, $/y.	Total	X				X	X	X	X		X
2	One table for each time interval calculated: damages by nuclide, $/y.	25 (1 table for each time interval-43)	X					X	X	X	X	X
3	Discounted Present Values , $, and $/y.	25			X					X	X	X
4-1	High Population Scenario: Number of Deaths Per Time Interval.	Total				X	X	X	X	X	X	
4-2	Low Population Scenario: Number of Deaths Per Time Interval.	Total				X	X	X	X	X		X
5-1	Total Undiscounted Damages for Each Zone for Each Time Interval-High Population, $.	Total		X			X	X	X	X	X	
5-2	Total Undiscounted Damages for Each Zone for Each Time Interval-Low Population, $.	Total		X			X	X	X	X		X

[a]Δt represents the length of time interval calculated.

PART 2

IMPLEMENTATION FOR TERMINAL STORAGE IN BEDDED SALT REFERENCE REPOSITORY

CHAPTER 7. STUDY REGION AND DIVISION INTO ZONES

CHAPTER 8. IMPLEMENTATION OF MODEL: BASE CASE

CHAPTER 9. IMPLEMENTATION OF MODEL: OTHER CASES

CHAPTER 10. DISCUSSION OF RESULTS

REFERENCE MATERIAL

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CHAPTER 7

STUDY REGION AND DIVISION INTO ZONES

A region within a radius of approximately 150 km from the proposed repository site is chosen for study. It is expected that most of any release of material would be dispersed within this region. To provide for non-uniform dispersal, population, and other factors, it is appropriate to divide the region into several zones. For this study, a division into 8 zones, As shown in Fig. 7-1, is used. Except as noted in following paragraphs, each zone is a county in New Mexico or a group of counties in Texas. This is a convenient basis which makes direct use of population and agricultural production data. For other applications, concentric annular zones are another basis for region subdivision may be used.

Population projections to the year 2020 are used in the economic model for damage calculations. For New Mexico, the UNM Bureau of Business Research supplied two projections (to be used as high and low), as seen in Table 7-1. A Texas projection was obtained from the Population Research Center of the University of Texas at Austin. This projection for Texas was calculated using the high New Mexico rate and assuming constant annual growth rate for 10 year intervals. Agricultural data is listed in Table 7-2. It should be noted that this region is largely desert and the percentage of land designated in farms is primarily unirrigated range land used for grazing livestock.

A circular zone with a radius of 5 km from the center of 10 km^2 assumed disposal site is designated as Zone 1. This zone, in Eddy County, New Mexico, has an area of 78.5 km^2; it represents a possible controlled area during the first several decades after start of the terminal storage phase. For computational purposes in the economic model the zone is considered to have a constant population of 101 individuals.

Zone 2 includes all of the arid land in Eddy County outside of Zone 1. Irrigated land in Eddy County comprises Zone 8, described later. Carlsbad Caverns National Park is in the southwest quadrant of Zone 2.

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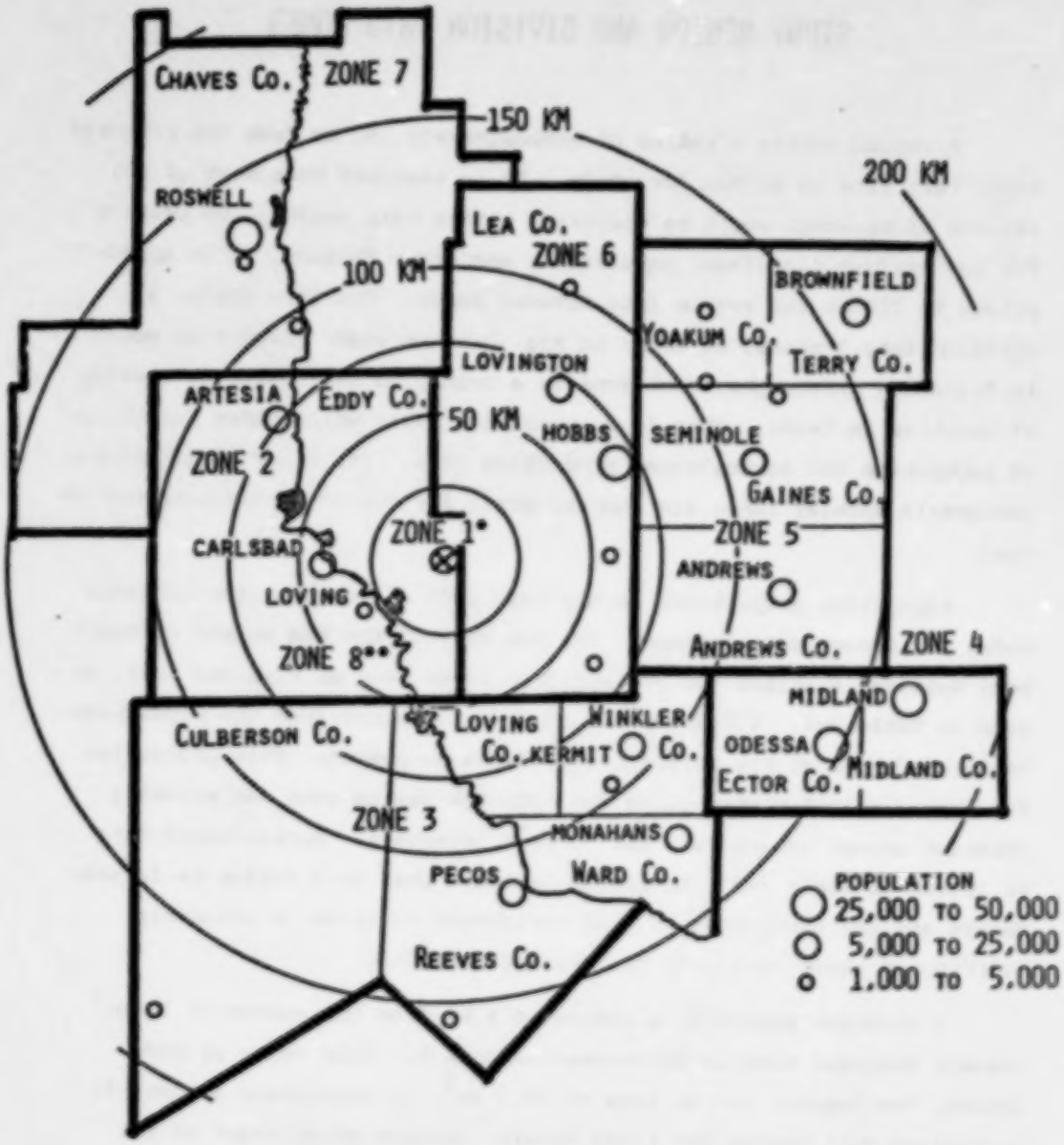


*Zone 1 is a 5 km radius area centered on the Los Medaños site.

**Zone 8 is a 4 km corrider centered on the Pecos River in Eddy County

Figure 7 - 1. Study region and zones.

Table 7-1. High and Low Population Projections 1970-2020

			High			
			ZONE			
YEAR	1+2+8 *	3	4	5	6	7
1970	41,119	42,778	157,237	43,452	49,552	43,335
1980	66,500	77,813	286,014	79,039	84,600	92,400
1990	85,350	101,935	374,678	103,541	112,450	121,900
2000	104,200	126,135	436,629	128,122	140,300	151,400
2010	138,050	169,650	587,266	172,324	192,850	202,250
2020	171,900	213,168	783,533	216,526	245,400	253,100
			Low			
1970	41,119	42,778	157,237	43,452	49,554	43,335
1980	44,000	38,236	163,406	43,462	53,600	47,800
1990	48,000	36,778	173,634	42,231	58,400	52,400
2000	52,000	39,099	188,319	45,547	63,200	57,000
2010	56,500	44,678	204,314	50,599	68,600	62,400
2020	61,000	53,578	224,047	57,869	74,000	67,800

*Values for Zones 1+2+8 are totals for Eddy County.

Estimated breakdown used for year 2020:

Zone	High	Low
1	101	101
2	17,200	6,100
8	155,000	54,900

Table 7-2. Land Use Patterns for 1969 by Zone[a]

	1+2+8[b]	3	4	5	6	7
Approximate land area (1000 hectares)[c]	1079	2284	478	1223	1138	1576
Land in farms (1000 hectares)	435	1944	495	899	939	1089
% of Land in Farms	40	85	109	73	83	69
Irrigated land (1000 hectares)	22	32	6	153	22	35
% of Farm Land Irrigated	5.0	1.6	1.2	17.0	2.3	3.2
All Cattle (1000's)	55	100	39	53	71	140
Milk Cows	721	679	360	384	1680	2490
All Hogs (1000's)	4.5	1.8	1.6	14.8	6.4	5.2
All Sheep (1000's)	43.8	1.3	12.9	15.6	21.3	165.7
Chickens (1000's)	200	16.5	59.6	282.9	28.2	21.7
Field Corn for Grain (1000 kilograms)	191	0	3	145	228	413
Sorghum for Grain or Seed (1000 kilograms)	2598	7208	3830	239050	18872	4941
Wheat for Grain (1000 kilograms)	47	3849	120	11824	118	470
Soybeans for Beans (1000 kilograms)	0	0	0	824	433	0
Hay (1000 Metric tons)	115	4.8	6.3	52	30	193
Cotton (1000 kilograms)	5282	14063	2539	51131	3355	7315

[a]As listed in the Census of Agriculture 1969.

[b]Values listed for zones 1+2+8 are totals for Eddy County.

[c]1 hectare = 10^4 m^2 = 0.01 km^2.

Five Texas counties comprise Zone 3. The counties are Culberson, Reeves, Loving, Ward, and Winkler. This zone, due to the Pecos River running through it, could potentially receive a share of any radiation release through the air and water medium. Zone 3 only had 1.6% of its farm land in irrigation (Table 7-2) whereas 85% of the land is farmed. Thus, the primary impact of a release would be in terms of airborne dispersion of waste to crop land. The principal towns in the zone are Pecos and Kermit with an overall population density of .019 people per hectare (1 hectare = 10^4 m^2 = 0.01 km^2).

The fourth zone includes the Texas counties of Midland and Ector. The principal towns are Midland and Odessa. The percent of farm land irrigated is only 1.2%. This irrigated water is most likely from ground water sources. Zone 4 has the highest population of 157,237 in 1970. Additionally the population density is the greatest, with .32 people per hectare.

Zone 5 includes the Texas counties of Andrews, Gaines, Terry and Yoakum. The principal towns are Andrews, Seminole, and Brownfield. The population density is .036 people per hectare. This zone has only 73% of its land area in farms but a high of 17% for all the zones is irrigated farm land. The principal crop of the zone is sorghum which is used primarily for grain and seed.

The sixth zone includes exclusively Lea County of New Mexico. The principal towns are Hobbs and Lovington. The population density is only .04 people per hectare. Additionally Zone 6 has 83% of its land area in farms.

Zone 7 is Chaves County of New Mexico. Roswell is the principal town in the zone. The population density is .027 people per hectare.

Zone 8 is a corridor along the Pecos River within Eddy County, consisting of the river bed, irrigated land and directly associated land. This is taken as 60,000 hectares, somewhat less than three times the area of irrigated land listed in Table 7-2. Zone 8 includes the cities of Artesia and Carlsbad, and most of the population in Eddy County. This zone is set up because of the concentrated belt of irrigated land, much of which is in the general direction of ground-water flow from the repository area.

From this discussion it is seen that in the zones surrounding the repository, agriculture is the predominant activity, with few large urban areas. The population projections imply that the population mix between the zones will remain relatively constant over time. Thus, development of large metropolitan centers in the zones is not expected; most likely a predominant role will continue to be played by agriculture.

CHAPTER 8

IMPLEMENTATION OF MODEL: BASE CASE

The base case is the primary vehicle used here for implementing the AMRAW model and computer code to the terminal storage phase at a reference high level waste repository. The reference site and study region, described in Chapter 7, is in the Los Medaños area in southeastern New Mexico, having thick deposits of bedded salt. It should be emphasized that this site was chosen here for study purposes to aid in development and demonstration of AMRAW, and does not represent present planning for the area. It is expected that there will ultimately be as many as six repositories in the United States for commercial high level waste; whether commercial waste will or will not be included in a repository at the Los Medaños site is not known. The study region surrounding the reference site is divided into the eight geographic zones shown earlier in Fig. 7-1.

The base case is run in the probabilistic distribution mode in which several geologic disturbance events are considered: severe earthquake, volcanism, meteorite impact, and surface erosion. Potential releases to four environmental receptors (air, land surface, surface water, and ground water) are calculated for the 25 most significant selected radionuclides. Calculations use 50 times over a range of one million years. Subsequent dose rates to 8 human organs (including total body) are calculated.

In Chapter 9, other cases are described in which discrete events are assumed at various times and the consequences are evaluated.

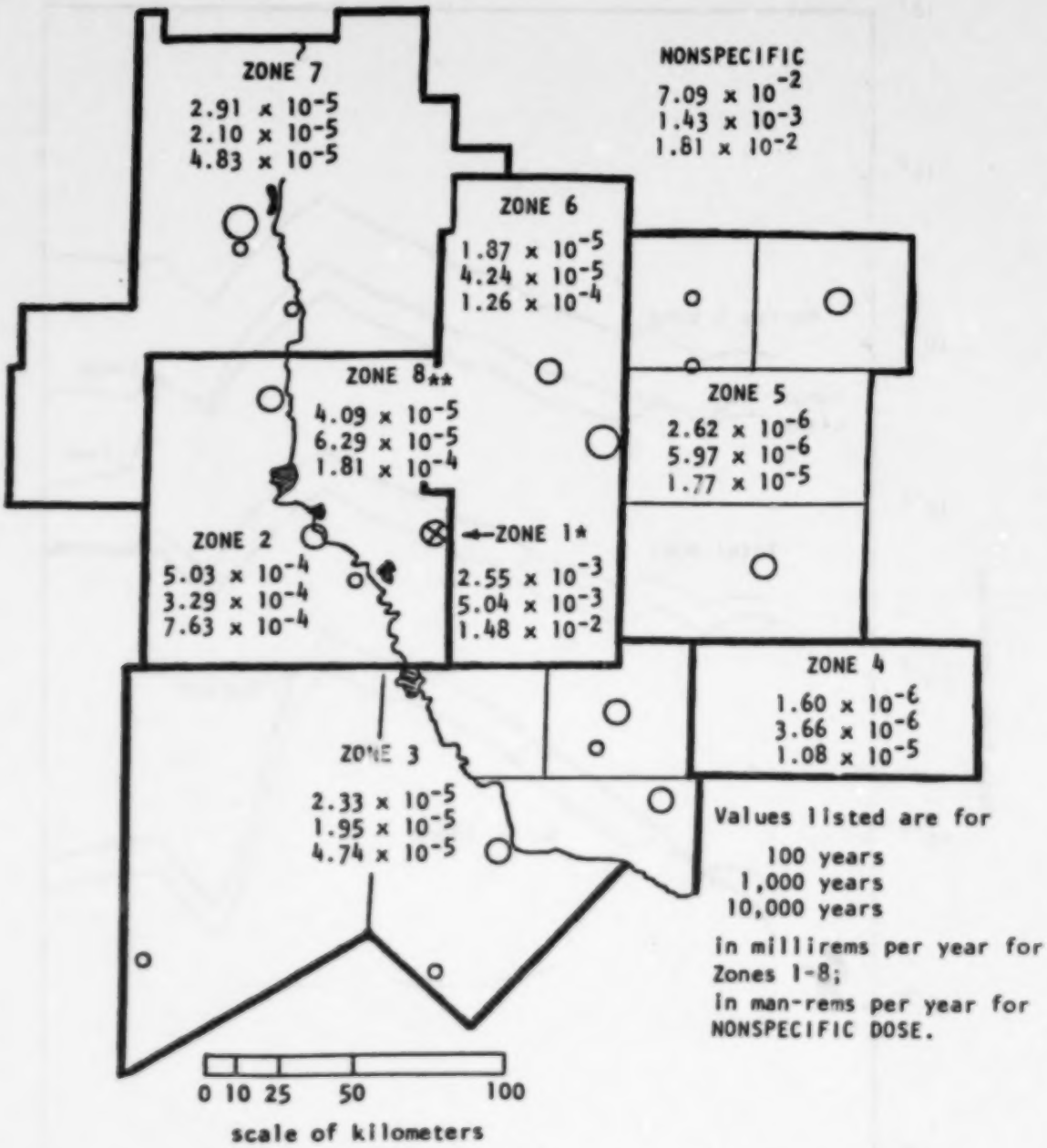
The following sections in this chapter describe the input data and results of calculations for the major steps in AMRAW-B: health effect evaluation, and economic analysis. The last step in the economic analysis, attribution of damages to elements in the initial inventory is presently performed externally to AMRAW-B.

A. SUMMARY OF CALCULATED DOSE RATES FROM AMRAW-A.

The major input data to AMRAW-B is the large output matrix of dose rates from AMRAW-A. The arrangement of this matrix by zone (and nonspecific category), nuclide, time increment, and body site (organ) is shown earlier in Table 6-1. Local dose in each geographic zone refers to dose from pathways which have a direct effect on the population within each zone. These are: immersion in air, inhalation, exposure to contaminated land surface, and submersion in and ingestion of contaminated water. Nonspecific dose is the dose associated with agricultural comodities, most of which are exported from the zones where grown. The affected population includes persons living within the study region but it is primarily an unspecific external population.

Each of the 225 dose rate output tables, for a given zone (or nonspecific category) and radionuclides, lists the average dose equivalent rate to each organ during each time increment. Appendix B is a sample of AMRAW-A output: table of local dose rates for Ra-226 in Zone 2 and table of nonspecific dose rates for Ra-226. When stripped of headings and the column of times, a large input file, ECON48, with 11,250 lines and 90,000 data items results.

Figure 8-1 (repeated from Vol. II) summarizes total body dose rates in each zone and the corresponding nonspecific dose rates at several times. Figure 8-2 illustrates dose rate variations for each organ in Zone 1, totaled for all nuclides and Fig. 8-3 is the corresponding nonspecific dose. It should be noted that the nonspecific category draws from all zones. The abrupt upsweep near 10^6 y is due to breakthrough of Np in ground water after 800,000 y. More complete summaries of base case calculated dose rates are given in Vol. II, Part 1.



* Zone 1 is a 5 km radius area centered on the Los Medaños site.

**Zone 8 is a 4 km wide corridor centered on the Pecos River in Eddy County.

Figure 8 - 1. Calculated total body dose rates for all nuclides.

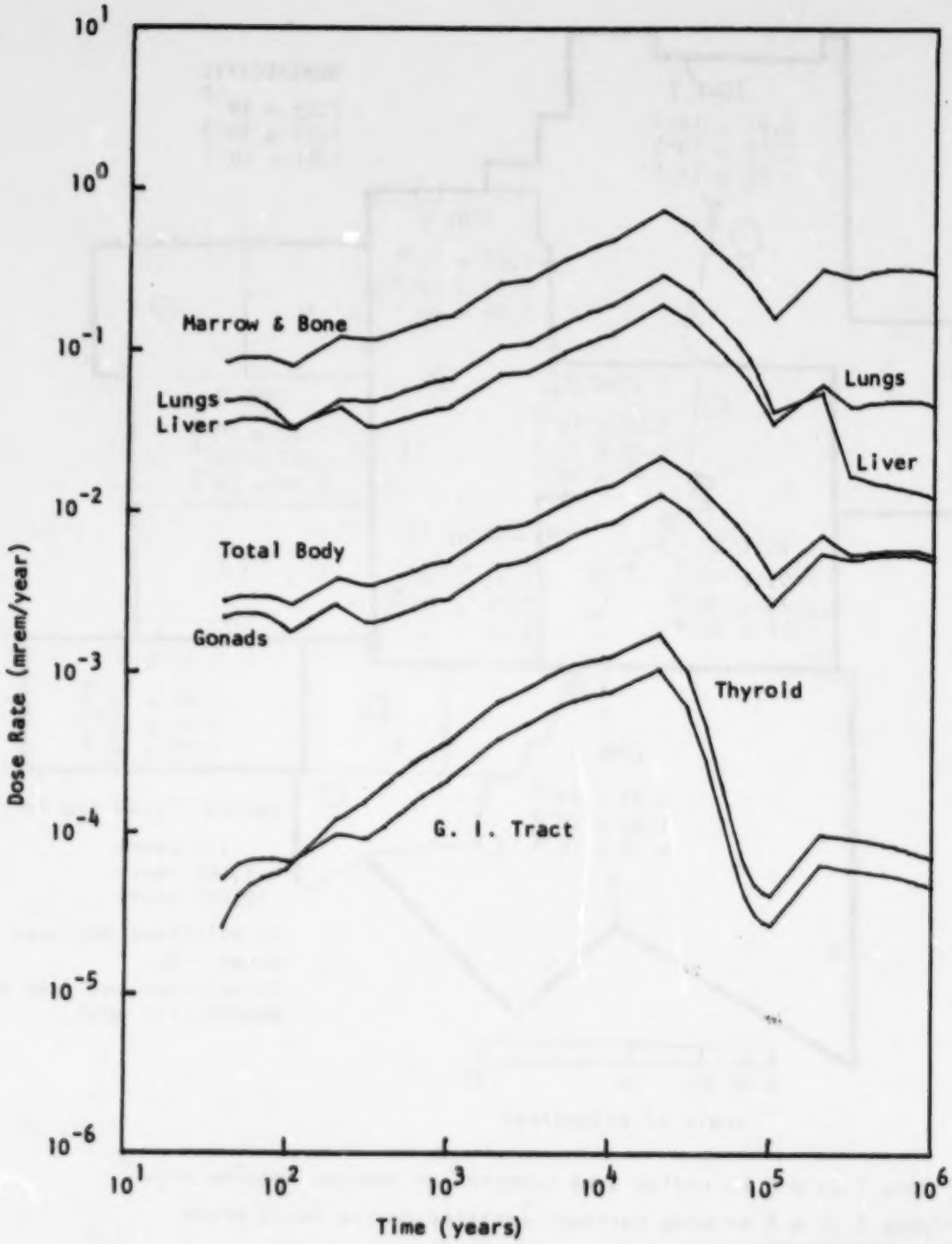


Figure 8 - 2. Average annual local dose to individual for each organ in Zone 1 from all nuclides.

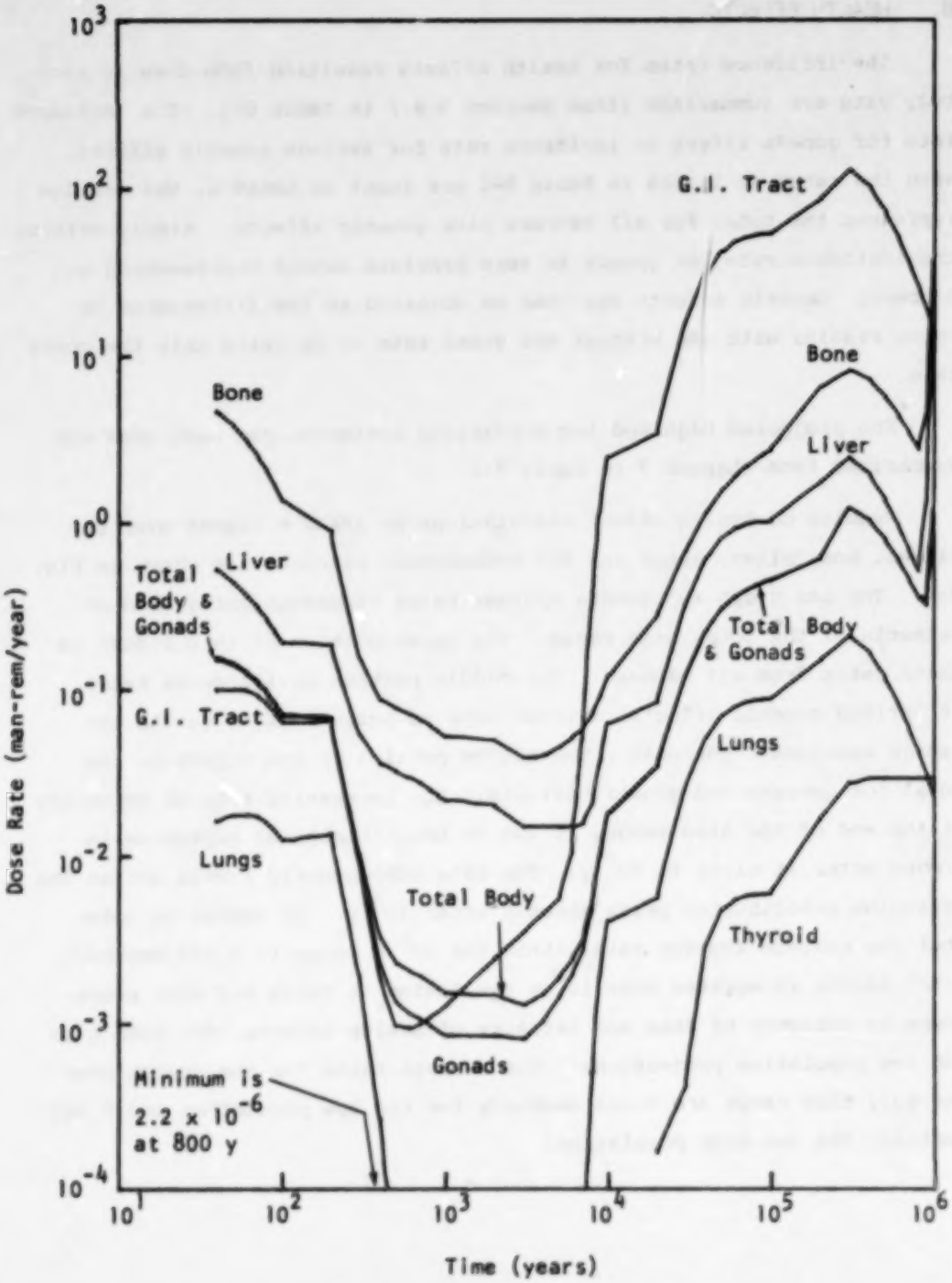


Figure 8-3. Average annual nonspecific dose to population for each organ from all nuclides.

B. HEALTH EFFECTS

The incidence rates for health effects resulting from dose to each body site are summarized (from Section 5.B.) in Table 8-1. The incidence rate for gonads refers to incidence rate for serious genetic effects. When the rates as listed in Table 8-1 are input to AMRAW-B, the results represent the total for all cancers plus genetic effects. Simply setting the incidence rate for gonads to zero provides output representing all cancers. Genetic effects may then be obtained as the differences between results with and without the gonad rate or by using only the gonad rate.

The projected high and low population estimates for each zone are summarized from Chapter 7 in Table 8-2.

Results of health effect calculations by AMRAW-B summed over nuclides, body sites, zones and the nonspecific category are shown in Fig. 8-4. The bar graph represents average rates of deaths per year over segments of the total time range. The upper portion of this figure is death rates from all cancers. The middle portion is incidence rates of serious genetic effects, treated here as equivalent to deaths for damage assessment purposes. The bottom portion of the figure is the total for cancers and genetic effects. The increasing rate of mortality at the end of the time range, is due to breakthrough of neptunium in ground water at close to 10^6 y. The rate subsequently levels out as the neptunium contribution peaks shortly after 10^6 y. It should be noted that the maximum average rate within the 10^6 y range is 0.005 deaths/y. Total deaths integrated over 10^6 y are listed in Table 8-3 with breakdowns by category of dose and category of health effects, for both high and low population projections. The average rates for the region over the full time range are 0.003 deaths/y for the low population and 0.005 deaths/y for the high population.

Table 8-1. Summary of Health Effects Incidence Rates

AMRAW-A Dose Rate Site	Incidence Rate Deaths Per 10^6 man-rem
Total Body	85[a]
G.I. Tract	34
Gonads	200
Liver	0
Lung	44
Bone Marrow	32
Bone	7
Thyroid	0

[a]Incidence rate for total body dose includes cancers for sites not specifically calculated.

Table 8-2. Population Projection for Year 2020[a]

Zone No.	Zone Name	High	Low
1	REPD	100	100
2	EDDY	17,200	6,100
3	REDB	213,000	53,600
4	MIDO	784,000	224,000
5	WTEX	217,000	57,900
6	LEA	245,000	74,000
7	CHAV	253,000	67,800
8	REG8	155,000	54,900
	TOTAL	1,884,300	538,400

[a]1970 total was 377,500.

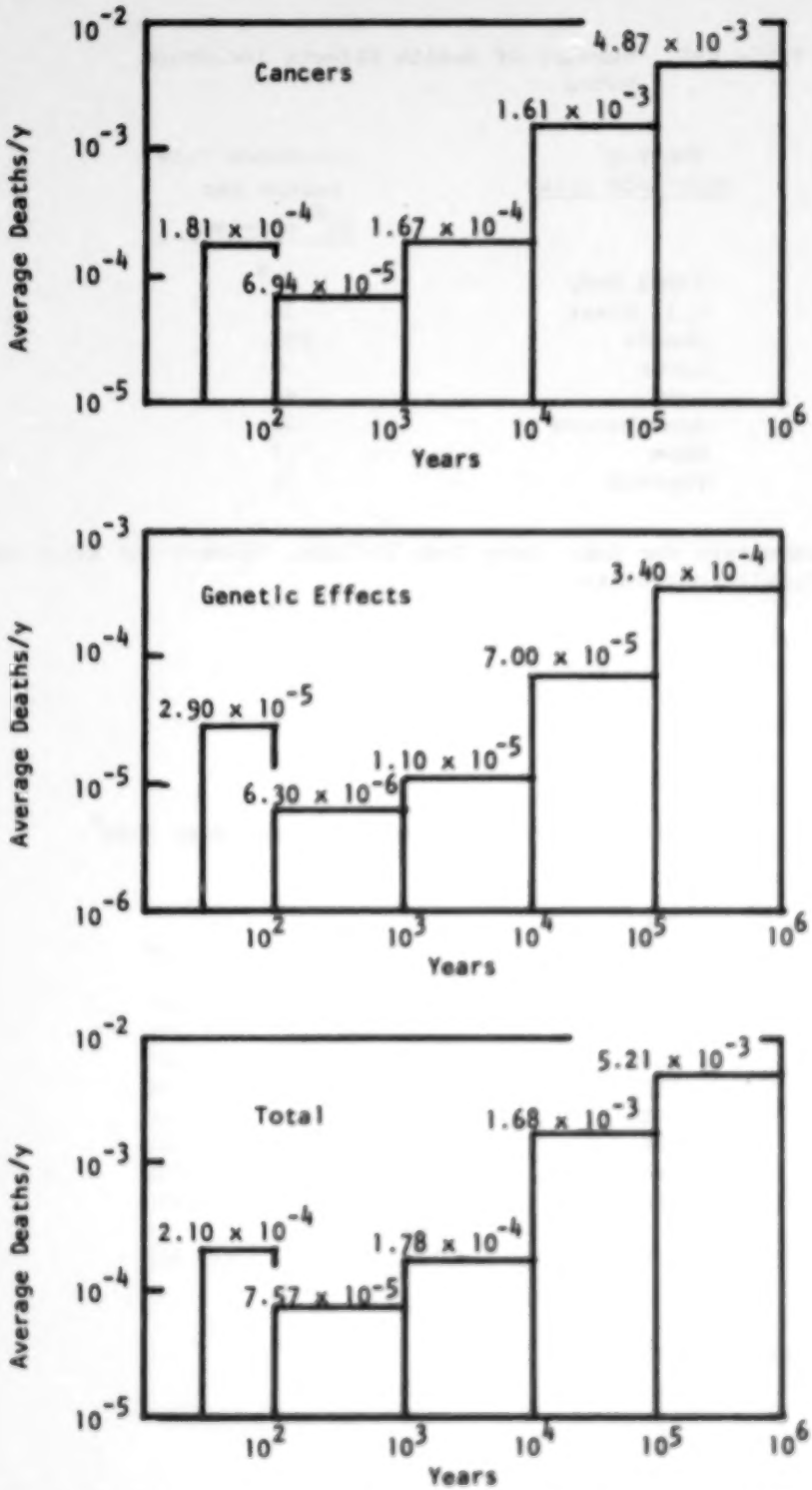


Figure 8-4. Average death rates from health effects, for high population projection, Case 48 (Base Case).

Table 8-3. Deaths in One Million Years from Health Effects[a]

High Population	Local[b] Deaths/10^6 y	Nonspecific Deaths/10^6 y	Total Deaths/10^6 y	Average Rate Deaths/y
Cancers	2.45×10^3	2.08×10^3	4.53×10^3	4.53×10^{-3}
Genetic Effects	1.80×10^2	1.30×10^2	3.10×10^2	3.10×10^{-4}
Total	2.63×10^3	2.21×10^3	4.84×10^3	4.84×10^{-3}
Low Population				
Cancers	8.66×10^2	2.08×10^3	2.94×10^3	2.94×10^{-3}
Genetic Effects	6.20×10^1	1.30×10^2	1.90×10^2	1.90×10^{-4}
Total	9.28×10^2	2.21×10^3	3.13×10^3	3.13×10^{-3}

[a]Case 48 (Base Case).

[b]"Local" is total for all zones.

C. ECONOMIC ANALYSIS

The dollar value of risk of death presented in Section 5.B. is based upon small increases in that risk. Using the value of $260 per year associated with an increase in risk of 10^{-3} per year, the lower bound value of $260,000 per statistical death is obtained; this is the value input to AMRAW-B. This provides a measure of potential environmental damage, in economic units, for comparison purposes. Zero discount rate is used for this analysis.

Output from AMRAW-B for the base case (Case 48) is in Appendix C. This output is for all health effects: all cancers plus genetic effects. The first non-zero values appear opposite a time of 40 y, representing the time increment 30 - 40 y. This is the first time increment for the terminal storage phase. Earlier times through 30 y represent the repository operations phase, treated by separate application of AMRAW. In Appendix C, Table 2 as numbered by AMRAW-B is sampled; full output includes one table for each time increment and 10 are presented here.

Table 8-4 summarizes results in $\$/10^6$ y and average rates, $/y, with breakdowns by category of dose and category of health effect, for both high and low population projections. This table corresponds to earlier Table 8-3 which lists deaths from health effects. The average rate of damage for the base case conditions is $1,260 per year for high population and $815 per year for low population projections. Estimated genetic effects comprise slightly over 6% of the total.

The breakdown of the total damage, in dollars, by nuclide decay Group and the corresponding marginal damage, $/gram, is given in Table 8-5. The first four decay groups shown are the thorium, neptunium, uranium, and actinium decay series, respectively. The greatest marginal damage results from Group 3 (uranium series) with $10/gram, followed by Group 2 (neptunium series) with $6.79/gram and Tc-99 (Group 8) at $3.13/gram. The other groups all fall below $0.08/gram and the net average for the total inventory is $1.57/gram. The next section of this chapter presents attribution of damages to individual elements in the initial waste inventory instead of by decay group.

Figure 8-5 is a plot of damage rate, $/y, versus time for the high population projection, showing local and nonspecific components as well

Table 8-4. Total Damages in One Million Years, in Dollars[a]

	Local $	Nonspecific $	Total $	Average Rate $/y
High Population				
Cancers	6.38×10^8	5.40×10^8	1.18×10^9	1,180.
Genetic Effects	4.60×10^7	3.30×10^7	8.00×10^7	80.
Total	6.84×10^8	5.73×10^8	1.26×10^9	1,260.
Low Population				
Cancers	2.25×10^8	5.40×10^8	7.65×10^8	765.
Genetic Effects	1.60×10^7	3.30×10^7	5.00×10^7	50.
Total	2.41×10^8	5.73×10^8	8.15×10^8	815.

[a]Case 4B (Base Case).

[b]"Local" is total for all zones.

Table 8-5. Total Damage and Average Marginal Damage by Nuclide Decay Groups[a]

NUCLIDE DECAY GROUP											
1	2	3	4	5	6	7	8	9	10	11	Total
Cm-244 Pu-240	Pu-241 Am-241 Np-237 Th-229 Ra-225	Am-242m Cm-242 Pu-238 Th-230 Ra-226 Pb-210	Am-243 Np-239 Pu-239	C-14	Sr-90 Y-90	Zr-93 Nb-93m	Tc-99	I-129	Cs-135	Cs-137	
Total Damages, $:											
3.72×10^{5}	7.06×10^{8}	6.52×10^{7}	3.51×10^{6}	3.16×10^{1}	4.21×10^{3}	3.46×10^{4}	4.82×10^{8}	4.58×10^{3}	2.56×10^{4}	1.17×10^{3}	1.26×10^{9}
Mass in Repository, grams:[b]											
4.37×10^{7}	1.04×10^{8}	6.50×10^{6}	7.96×10^{7}	4.04×10^{4}	6.28×10^{7}	1.33×10^{8}	1.54×10^{8}	5.84×10^{4}	6.80×10^{7}	1.52×10^{8}	8.04×10^{8}
Average Marginal Damage, $/gram:											
8.51×10^{-3}	6.79	10.0	4.41×10^{-2}	7.82×10^{-4}	6.70×10^{-5}	2.60×10^{-4}	3.13	7.84×10^{-2}	3.76×10^{-4}	7.70×10^{-6}	1.57

[a]Case 48 (Base Case), for high population projection, integrated over 10^{6} y.

[b]Repository inventory refers to the beginning of the terminal storage phase.

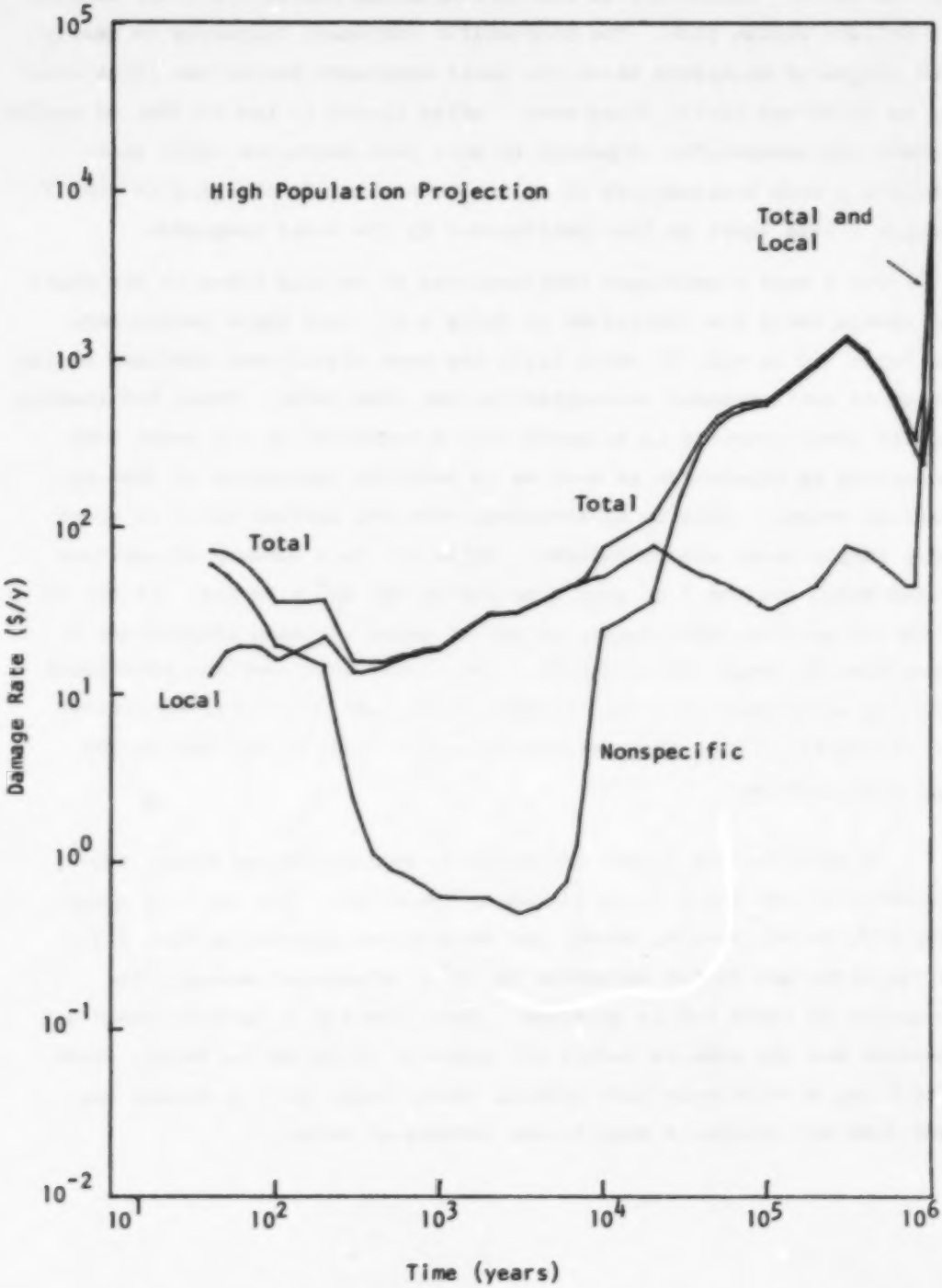


Figure 8-5. Components and total damage rates for base case.

as the total. Figure 8-6 is the corresponding cumulative total damages in dollars versus time. The nonspecific component decreases to nearly two orders of magnitude below the local component during the first 1000 y, as Sr-90 and Cs-137 decay away. After 10,000 y, the buildup of Ra-226 causes the nonspecific component to move into dominance until about 900,000 y when breakthrough of Np in groundwater discharging in Zone 2 causes a late spurt in the contribution by the local component.

The 5 most significant radionuclides at various times on the basis of damage rates are identified in Table 8-6. This table corresponds to Table 8-3 in Vol. II which lists the most significant nuclides on the bases of environmental concentrations and dose rates. Table 8-6 ranking in the local category is automatically a composite of all zones with weighting by population as well as by relative importance of dose to various organs. This is an advantage over the earlier table in which only sample zones are considered. Table 8-7 is a summary of nuclides cited among the top 5 at some time during the 10^6 y period. Of the 25 selected nuclides considered, 16 appear among the most significant at some time in damage calculations. The significant nuclides identified identified in Table 8-7, are generally the same as identified earlier on the basis of dose rates except Table 8-7 drops Cs-135 and Th-230 and adds Am-242m.

If nuclides are ranked according to maximum damage rates, the sequence of the top 8 is as listed in Table 8-8. The top 5 of these (Np-237, Tc-99, Ra-226, Sr-90, and Am-243) are plotted in Fig. 8-7. If nuclides are ranked according to 10^6 y integrated damages, the sequence in Table 8-9 is obtained. Here, the top 3 (Np-237, Tc-99 and Ra-226) are the same as before and comprise 97.4% of the total; Sr-90 which has a relatively high initial damage rate, quickly decays away and does not produce a significant integrated total.

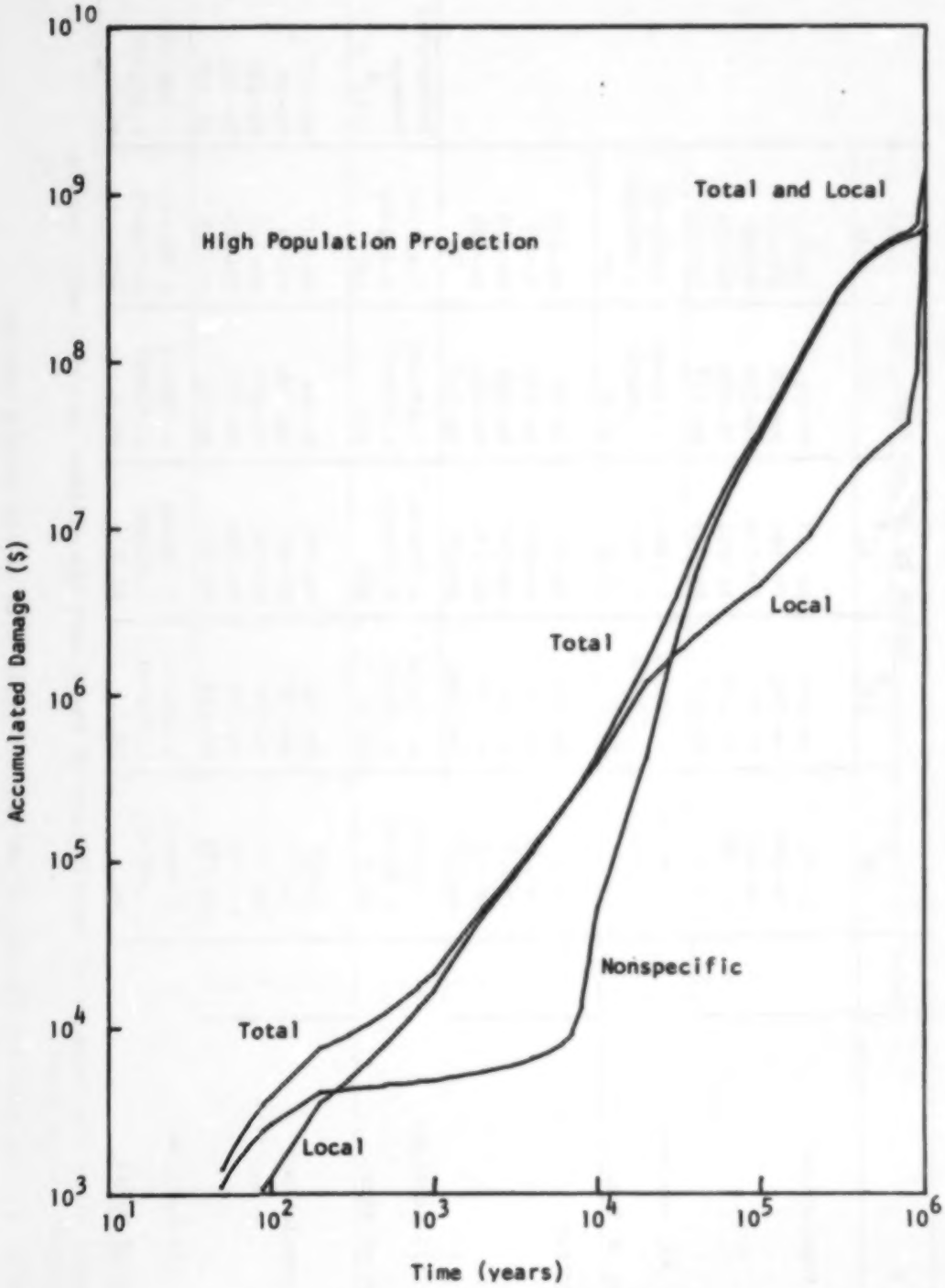


Figure 8-6. Accumulated components and total damage for base case.

Table 8-6. Most Significant Radionuclides Versus Time for the Base Case

Time, y	Order[a]	Ranked by Damage Rate, $/y					
		10^2	10^3	10^4	10^5	10^6	
LOCAL (High Population)	1	Sr-90	Am-241	Am-243	Tc-99	Np-237	
	2	Cm-244	Am-243	Pu-240	Pu-239	Th-229	
	3	Am-241	Pu-240	Pu-239	Ra-226	Tc-99	
	4	Pu-238	Pu-239	Am-241	Th-229	Ra-226	
	5	Cs-137	Np-239	Np-239	Np-237	Ra-225	
Total, all nuclides		1.58E+01	1.87E+01	5.12E+01	3.19E+01	5.98E+03	
Top 5		1.47E+01	1.85E+01	5.04E+01	3.06E+01	5.98E+03	
Percent of Total		93.2	99.2	98.6	95.9	100	
NONSPECIFIC	1	Sr-90	Am-241	Tc-99	Tc-99	Np-237	
	2	Cs-137	Am-243	Ra-226	Ra-226	Tc-99	
	3	Cm-244	Tc-99	Am-243	Ra-225	Ra-226	
	4	Am-241	Pu-240	Ra-225	Pb-210	Ra-225	
	5	Am-243	Am-242m	Am-241	Np-237	b	
Total, all nuclides		1.96E+01	6.06E-01	2.43E+01	5.47E+02	5.65E+02	Integrated Damage $/$10^6$ y
Top 5		1.94E+01	6.03E-01	2.43E+01	5.47E+02	5.65E+02	
Percent of Total		99.2	99.5	100	100	100	
TOTAL (High Population)	1	Sr-90	Am-241	Am-243	Tc-99	Np-237	Np-237
	2	Cs-137	Am-243	Tc-99	Ra-226	Tc-99	Tc-99
	3	Cm-244	Pu-240	Pu-240	Pu-239	Ra-226	Ra-226
	4	Am-241	Pu-239	Pu-239	Th-229	Th-229	Th-229
	5	Pu-238	Np-239	Am-241	Np-237	Ra-225	Ra-225
Total, all nuclides		3.54E+01	1.93E+01	7.55E+01	5.79E+02	6.55E+03	1.26E+09
Top 5		3.40E+01	1.91E+01	7.36E+01	5.76E+02	6.55E+03	1.25E+09
Percent of Total		96.1	99.1	97.4	99.6	100	99.6

[a]The order lists the sequence of contribution of the 5 most significant nuclides, with the most significant listed first.

[b]The fifth ranking nuclide, Nb-93m, is omitted as it is < 1% of the fourth nuclide.

Table 8-7. Summary of Radionuclides Among the Five Most Significant at Some Time

No.	Nuclide	Damage Component		
		Local	Nonspecific	Total
Fission and Activation Products				
1	C-14			
2	Sr-90	X	X	X[a]
3	Y-90			
4	Zr-93			
5	Nb-93m			
6	Tc-99	X	X	X[a]
7	I-129			
8	Cs-135			
9	Cs-137	X	X	X
Actinides and Daughters				
10	Pb-210		X	
11	Ra-225	X	X	X
12	Ra-226	X	X	X[a]
13	Th-229	X		X[a]
14	Th-230			
15	Np-237	X	X	X[a]
16	Np-239	X		X
17	Pu-238	X		X
18	Pu-239	X		X[a]
19	Pu-240	X	X	X[a]
20	Pu-241			
21	Am-241	X	X	X
22	Am-242m		X	
23	Am-243	X	X	X[a]
24	Cm-242			
25	Cm-244	X	X	X
Number Checked		14	12	14

[a]Denotes nuclides with damage rate exceeding \$10/y at some time during 10^6 y.

Table 8-8. Most Significant Radionuclides Ranked by Maximum Damage Rate[a]

Rank	Nuclide	Peak Damage Rates Rate, $/y	Time, y
1	Np-237	6,360.	1,000,000
2	Tc-99	976.	400,000
3	Ra-226	116.	300,000
4	Sr-90	50.	40
5	Am-243	41.	20,000
6	Pu-239	24.	40,000
7	Th-229	22.	700,000
8	Pu-240	15.	20,000

[a]Based upon high population projection.

Table 8-9. Most Significant Radionuclides Ranked by 10^6 y, Integrated Damages.

Rank	Nuclide	Integrated Damage, $[a]
1	Np-237	6.82×10^8
2	Tc-99	4.82×10^8
3	Ra-226	6.31×10^7
4	Th-229	1.77×10^7
5	Ra-225	7.16×10^6
6	Pu-239	2.47×10^6
7	Th-230	1.13×10^6
8	Am-243	1.03×10^6
Total		1.26×10^9

[a]Based upon high population projection.

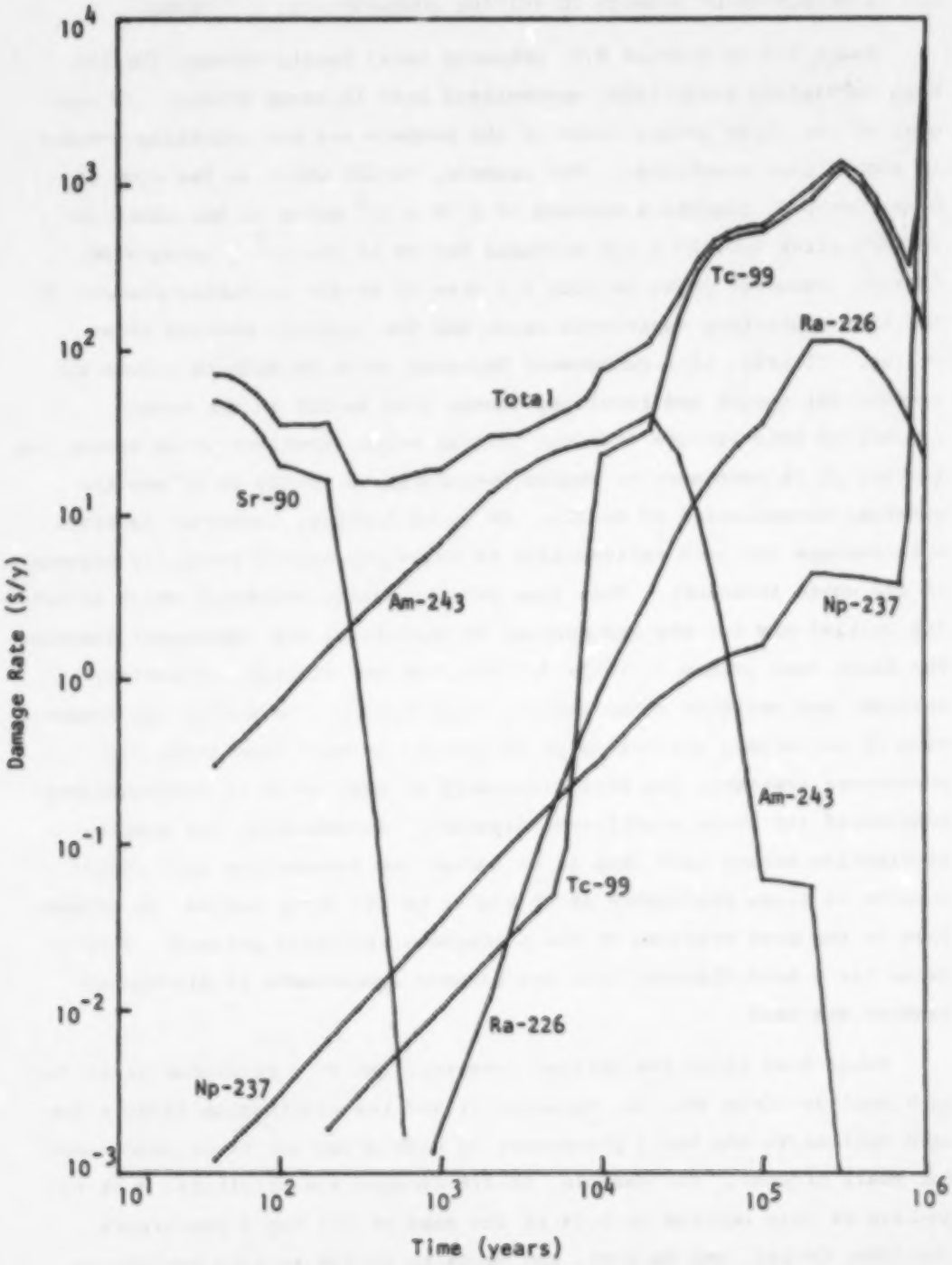


Figure 8-7. Total damage rates for most significant radionuclides.

D. ATTRIBUTION OF DAMAGES TO INITIAL INVENTORY (S. E. LOGAN)

Table 8-5 in Section 8.C. presents total health damages for the high population projection, accumulated into 11 decay groups. In several of the decay groups, some of the members are not initially present in significant quantities. For example, Ra-226 which is far down in Decay Group 3, reaches a maximum of 2.79×10^4 grams in the waste inventory after 200,000 y and accounts for 5% of the 10^6 y integrated damage. However, there is only 0.1 gram of Ra-226 initially present at the time repository operations cease and the terminal storage phase begins. Clearly, if a management decision is to be made to reduce environmental impact and resulting damage from Ra-226 in the waste, removal of this isotope from the initial waste inventory would accomplish little; it is necessary to remove precursors of Ra-226 to reduce the eventual accumulation of Ra-226. It is of interest therefore to attribute damages for each radionuclide to those precursors initially present in the waste inventory. This then permits making decisions which affect the initial mix for the end purpose of minimizing the subsequent damages. The first four groups in Table 8-5 are from the thorium, neptunium, uranium, and actinium decay series, respectively. Initially (at cessation of repository operations at 30 years), no more than three top precursors represent the total inventory of each group of radionuclides considered (to three significant figures). Accordingly, the simple attribution scheme used here is to assign the damages for each radionuclide to those precursors at or higher in its decay series, in proportion to the mass fraction of the precursors initially present. This is valid for a zero discount rate but becomes approximate if discounted damages are used.

Table 8-10 lists the initial inventory (at 30 y reference time) for each nuclide (from Vol. II, Appendix J) and the attribution factors for each nuclide to the top 3 precursors in each group (or fewer precursors for small groups). For example, Ra-226 damages are attributed 9.6% to Am-242m as this nuclide is 9.6% of the mass of the top 3 precursors (Am-242m, Cm-242, and Pu-238), and 90.4% to Pu-238 as this nuclide is the corresponding percentage of the mass of the top 3 precursors. Conversely, if Pu, and hence Pu-238, were removed from the waste, 90.4% of

Table 8-10. Attribution Factors

Decay Group	Nuclide	Initial Inventory Grams	Precursors in Group and Attribution Factors, Percent		
1			Cm-244	Pu-240	
	Cm-244	2.04E+7[a]	100.		
	Pu-240	2.33E+7	46.7	53.3	
2			Pu-241	Am-241	Np-237
	Pu-241	8.47E+5	100.		
	Am-241	1.93E+7	4.2	95.8	
	Np-237	8.35E+7	0.8	18.6	80.6
	Th-229	3.60E+1	0.8	18.6	80.6
	Ra-225	1.96E-4	0.8	18.6	80.6
3			Am-242m	Cm-242	Pu-238
	Am-242m	6.23E+5	100.		
	Cm-242	1.50E+3	99.8	0.2	
	Pu-238	5.88E+6	9.6		90.4
	Th-230	2.21E+2	9.6		90.4
	Ra-226	9.94E-2	9.6		90.4
	Pb-210	4.51E-4	9.6		90.4
4			Am-243	Np-239	Pu-239
	Am-243	7.25E+7	100.		
	Np-239	6.00E+1	100.		
	Pu-239	7.13E+6	91.0		9.0
5			C-14		
	C-14	4.04E+4	100.		
6			Sr-90		
	Sr-90	6.28E+7	100.		
	Y-90	1.63E+4	100.		
7			Zr-93		
	Zr-93	1.33E+8	100.		
	Nb-93m	7.45E+2	100.		
8			Tc-99		
	Tc-99	1.54E+8	100.		
9			I-129		
	I-129	5.84E+4	100.		
10			Cs-135		
	Cs-135	6.80E+7	100.		
11			Cs-137		
	Cs-137	1.52E+8	100.		

[a] 2.04E+7 denotes 2.04×10^7. Inventory is at the end of repository operations, at 30 y.

the damages from accumulation of Ra-226 would be avoided.

Table 8-11 applies the attribution factors from Table 8-10 to the total damages for each nuclide (from Appendix C, Table 3) and lists the resulting attributed damages. One more step is involved. Any change in inventory by partitioning for separate disposal or transmutation of one or more segregated fractions of the waste involves chemical processing. Unless and until advanced technology for isotopic separation becomes operational, separation by chemical elements must be used. Therefore, the attributed damages to precursor nuclides in Table 8-11 are collected by elements, and listed in Table 8-12 for the 10 significant elements present. This summary indicates that for the base case conditions, 45% of the damages integrated over 10^6 y are due to Np initially present in the waste inventory. This is followed in importance by Tc (38%), Am (11%) and Pu (5%). These four elements account for all but 0.02% of the total damages. It should be noted, however, that the ground water velocity used here was conservatively increased by a factor of 6 over the estimated velocity to cover uncertainty. If a factor of 4 were used instead of 6, breakthrough of Np would be deferred to beyond the 10^6 y range calculated, and the impact of Np would be reduced.

The attribution of damages to elements in the initial inventory is presently performed externally to AMRAW as shown here, using AMRAW-B output and inventory mass data. While the simple attribution scheme can be incorporated in AMRAW-B, this has been deferred pending development of a more rigorous scheme.

Table 8-11. Attribution of Total Damages to Initial Radionuclides in Inventory

Decay Group	Nuclide	Total Damages $	Precursors and Attribution of Damages, $		
1			Cm-244	Pu-240	
	Cm-244	9.58E+2[a]	9.58E+2		
	Pu-240	3.71E+5	1.37E+5	1.98E+5	
			1.74E+5	1.98E+5	
2			Pu-241	Am-241	Np-237
	Pu-241	5.77E+2	5.77E+2		
	Am-241	8.99E+4	3.78E+3	8.61E+4	
	Np-237	6.82E+8	5.46E+6	1.27E+8	5.50E+8
	Th-229	1.77E+7	1.42E+5	3.29E+6	1.43E+7
	Ra-225	7.16E+6	5.73E+4	1.33E+6	5.77E+6
			5.66E+6	1.32E+8	5.70E+8
3			Am-242M	Cm-242	Pu-238
	Am-242m	2.17E+2	2.17E+2		
	Cm-242	1.05E+1	1.05E+1	2.10E-2	
	Pu-238	8.76E+2	8.41E+1		7.92E+2
	Th-230	1.13E+6	1.08E+5		1.02E+6
	Ra-226	6.31E+7	6.06E+6		5.70E+7
	Pb-210	9.85E+5	9.46E+4		8.90E+5
			6.26E+6	2.10E-2	5.89E+7
4			Am-243	Np-239	Pu-239
	Am-243	1.03E+6	1.03E+6		
	Np-239	1.53E+4	1.53E+4		
	Pu-239	2.47E+6	2.25E+6		2.22E+5
			3.30E+6	0.0	2.22E+5
5			Sr-90		
	Sr-90	4.18E+3	4.21E+3		
	Y-90	2.78E+1			
6			Zr-93		
	Zr-93	2.51E+3	3.46E+4		
	Nb-93m	3.21E+4			
7	Tc-99	4.82E+8	4.82E+8		
8	I-129	4.58E+3	4.58E+3		
9	Cs-135	2.56E+4	2.56E+4		
10	Cs-137	1.17E+3	1.17E+3		
11	C-14	3.16E+1	3.16E+1		
	Total	1.26E+9			

[a] 9.58E+2 denotes 9.58×10^2.

Table 8-12. Attribution of Damages to Initial Elements in Inventory.

Element	Total Damages $	Percentage of group	Percentage of total
Fission and Activation Products:			
C	3.16×10	6×10^{-6}	---
Sr	4.21×10^{3}	9×10^{-4}	---
Zr	3.46×10^{4}	7×10^{-3}	.003
Tc	4.82×10^{8}	100.	38.3
I	4.58×10^{3}	1×10^{-3}	---
Cs	2.68×10^{4}	6×10^{-3}	.002
Subtotal	4.82×10^{8}	100.	38.3
Actinides:			
Np	5.70×10^{8}	73.4	45.2
Pu	6.50×10^{7}	8.4	5.2
Am	1.42×10^{8}	18.3	11.3
Cm	1.74×10^{5}	0.02	0.01
Subtotal	7.77×10^{8}	100.	61.7
TOTAL	1.26×10^{9}		100.

CHAPTER 9

IMPLEMENTATION OF MODEL: OTHER CASES

The base case described in Chapter 8 is a computer run in the probabilistic mode in which several geologic disturbance events are considered. The probabilistic distribution represents operation of AMRAW in a risk mode where risk in this sense is defined as the product of probability of occurrence of an event and the consequence of an occurrence. (Elsewhere in this discussion of the Economic Model, the term risk is used in the economic sense as the chance of damage occurring.) Additional cases which consider individual release scenarios, different values for one or more of the parameters, or discrete events occurring at various times, are helpful in identifying the more important contributors to risk or consequences. Several series of cases in addition to the base case, run through AMRAW-A, are described in Vol. II. Five of these other cases, identified in Table 9-1, have been run through AMRAW-B for demonstration purposes. All of these cases (other than the base case) are for discrete events: a leach incident causing release to ground water and volcanic explosion release to air occurring at various times.

Table 9-1. Descriptions of Base Case and Other Cases

Case No.	Release Conditions
48	Base Case - all probabilistic release events.
50	Leach incident release to ground water, commencing at 100 y.
32	Volcanic explosion release to air, occurring at 1000 y.
33	Same as Case 32 except environmental decay rate increased, x 100.
34	Same as Case 32 except occurring at 10,000 y.
35	Same as Case 32 except occurring at 100,000 y.

Consider first Case 50 (Table 9-1), which is a leach incident iniated by offset faulting from a severe earthquake at a reference time of 100 y (70 y after cessation of repository operations). The probability of such an occurrence is estimated to be 1.4×10^{-7} per year (Vol. II). The calculations in AMRAW-A assume the fracture interconnects aquifers above and below the disposal horizon, that water flows upward, continuously leaches radionuclides from one row of waste canisters, and is intercepted by the flow in the upper aquifer. It is conservatively assumed that the fracture does not close and heal. Delays occur due to leach resistance and slow transport by ground water flow. Figure 9-1 shows the variation of damage rate with time determined by AMRAW-B. The steep rise after 5000 y occurs as Tc and I, which move unretarded with the ground water, begin to appear in Zone 2. The nonspecific category dominates and is coincident with the total over most of the time range. After about 800,000 y, breakthrough of Np in ground water begins in Zone 2 causing an upswing in the local components. Off scale, the Np contribution levels off after 10^6 y. Figure 9-2 is the corresponding accumulated (integrated) damages versus time. Figures 9-1 and 9-2 are for the high population projection and for damages from total cancers and genetic effects. Table 9-2 provides the total integrated damages in dollars for 10^6 y for low and high population, and the local and nonspecific components. Table 9-3 lists total deaths and total dollars, along with the components from somatic health effects (cancers) and genetic effects.

Next, consider volcanic explosion release to air. A volcanic eruption through an area such that any portion of the repository is intersected in a very unlikely occurrence, having an estimated probability of only 2.4×10^{-12} per year (Vol. II). The AMRAW-A calculations assume that 50% of repository inventory intersected is expelled into the atmosphere, is not reburied after dispersal and is of a physical and chemical form such that the radionuclides are immediately available for environmental processes. Figure 9-3 shows the response following a volcanic release at 1000 y and Fig. 9-4 is the corresponding accumulated damages versus time. The large dip in the nonspecific contribution is because this component is dominated in early years by Sr-90 and Cs-137, which largely disappear through decay during the first 1000 y, and in later years by Ra-226 which builds up after 10,000 y. The drop-off of

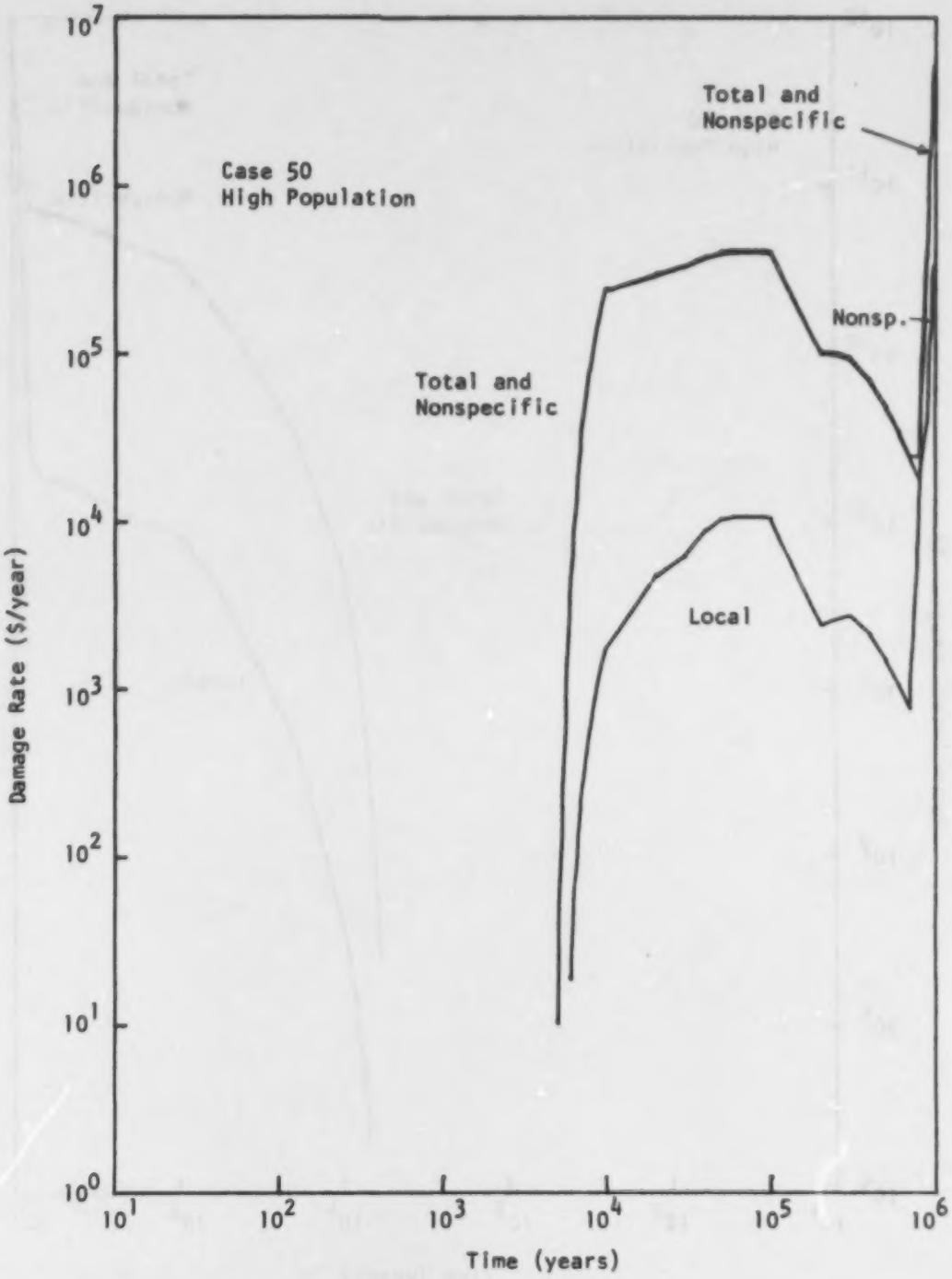


Figure 9-1. Damage rates following leach incident commencing at 100 y.

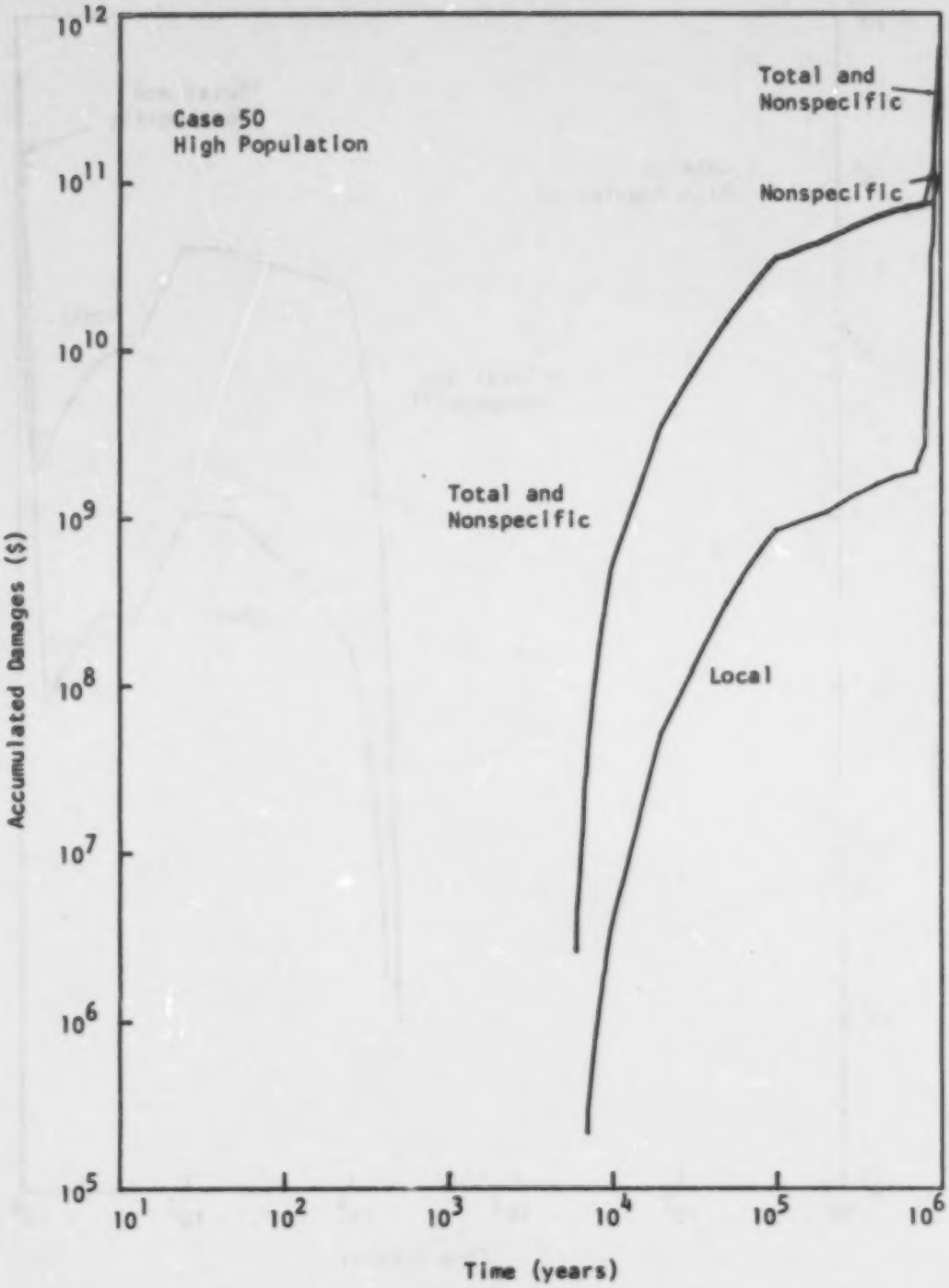


Figure 9-2. Accumulated damages following leach incident commencing at 100 y.

Table 9-2. Summary of Total Integrated Damages

Case No.	Description	Low Population, $\$/10^6$ y			High Population, $\$/10^6$ y		
		Local[a]	Nonspecific	Total	Local	Nonspecific	Total
48	Base Case - all probabilistic releases	2.41×10^8 (30%)[b]	5.73×10^8 (70%)[b]	8.15×10^8	6.84×10^8 (55%)	5.73×10^8 (45%)	1.26×10^9
50	Leach incident at 100 y	1.86×10^{11} (62%)	1.12×10^{11} (38%)	2.97×10^{11}	5.24×10^{11} (82%)	1.12×10^{11} (18%)	6.35×10^{11}
32	Volcano at 1000 y	2.50×10^{12} (75%)	7.80×10^{11} (25%)	3.28×10^{12}	7.37×10^{12} (90%)	7.80×10^{11} (10%)	8.15×10^{12}
33	Volcano at 1000 y Environmental decay, x 100	1.32×10^{11} (82%)	2.83×10^{10} (18%)	1.60×10^{11}	3.90×10^{11} (93%)	2.83×10^{10} (7%)	4.18×10^{11}
34	Volcano at 10,000 y	1.54×10^{12} (62%)	8.94×10^{11} (38%)	2.43×10^{12}	4.53×10^{12} (84%)	8.94×10^{11} (16%)	5.42×10^{12}
35	Volcano at 100,000 y	2.80×10^{11} (14%)	1.68×10^{12} (86%)	1.96×10^{12}	8.39×10^{11} (33%)	1.68×10^{12} (67%)	2.52×10^{12}

[a]Local is sum of all zones.

[b]Percentages indicate contributions by local and nonspecific categories to total.

Table 9-3. Summary of Somatic and Genetic Components of Total Integrated Damages

Case	Description	High Population					
		Deaths/10^6 y			$/$10^6$ y		
		Somatic	Genetic	Total	Somatic	Genetic	Total
48	Base case - all probabilistic releases	4.53×10^3 (94%)[a]	3.10×10^2 (6%)	4.84×10^3	1.18×10^9 (94%)	8.00×10^7 (6%)	1.26×10^9
50	Leach incident at 100 y	2.29×10^6 (94%)	1.50×10^5 (6%)	2.44×10^6	5.96×10^{11} (94%)	3.90×10^{10} (6%)	6.35×10^{11}
32	Volcano at 1000 y	2.87×10^7 (92%)	2.60×10^6 (8%)	3.13×10^7	7.47×10^{12} (92%)	6.80×10^{11} (8%)	8.15×10^{12}
33	Volcano at 1000 y Environ. decay, x 100	1.51×10^6 (94%)	1.00×10^5 (6%)	1.61×10^6	3.92×10^{11} (94%)	2.60×10^{10} (6%)	4.18×10^{11} (.05 x case 32)
34	Volcano at 10,000 y	1.88×10^7 (90%)	2.10×10^6 (10%)	2.09×10^7	4.89×10^{12} (90%)	5.30×10^{11} (10%)	5.42×10^{12} (.67 x case 32)
35	Volcano at 100,000 y	7.57×10^6 (78%)	2.11×10^6 (22%)	9.68×10^6	1.97×10^{12} (78%)	5.50×10^{11} (22%)	2.52×10^{12} (.31 x case 32)

[a]Percentages indicate contributions by somatic and genetic categories to total.

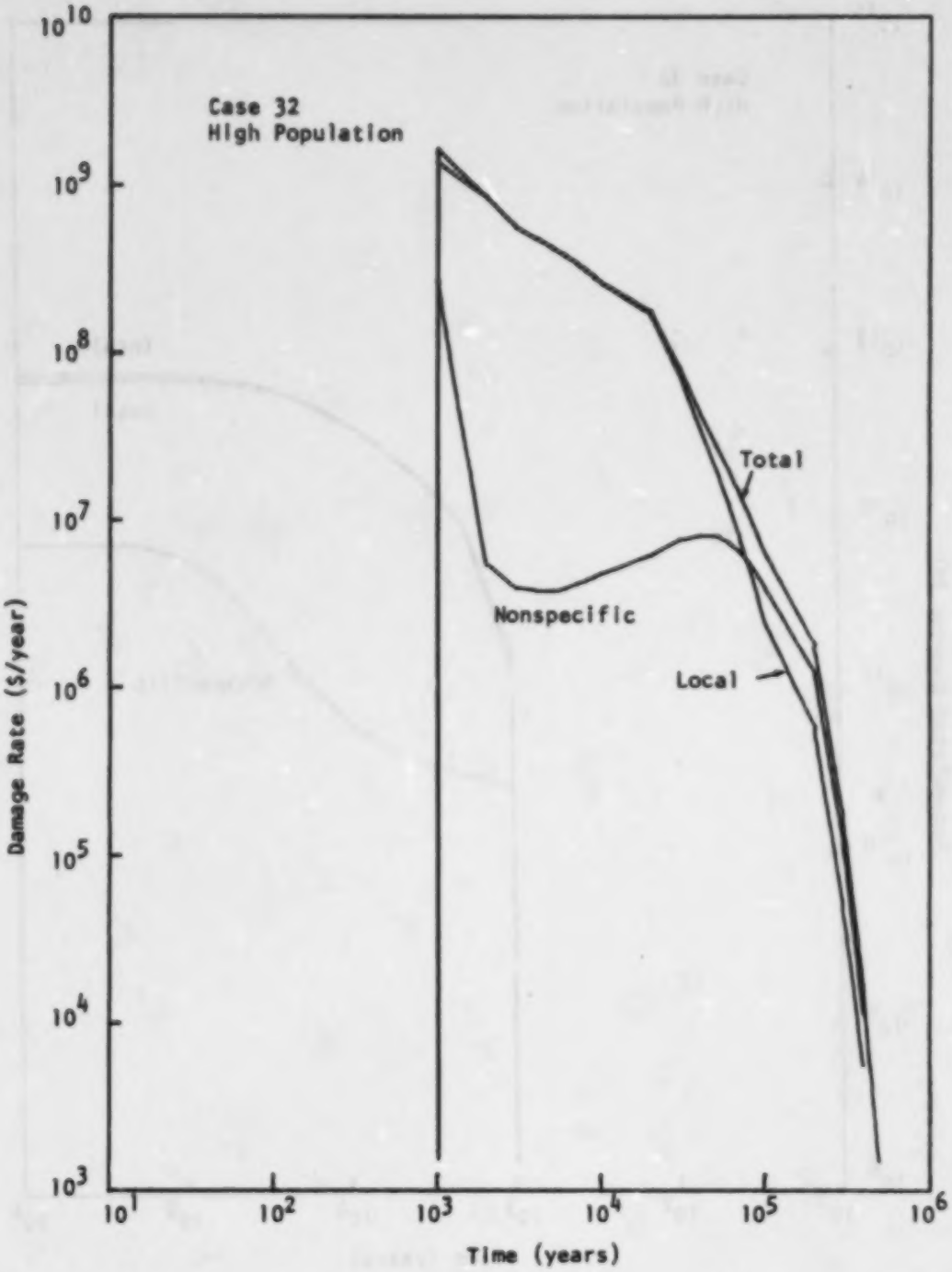


Figure 9-3. Damage rate following volcanic release to air at 1000 y.

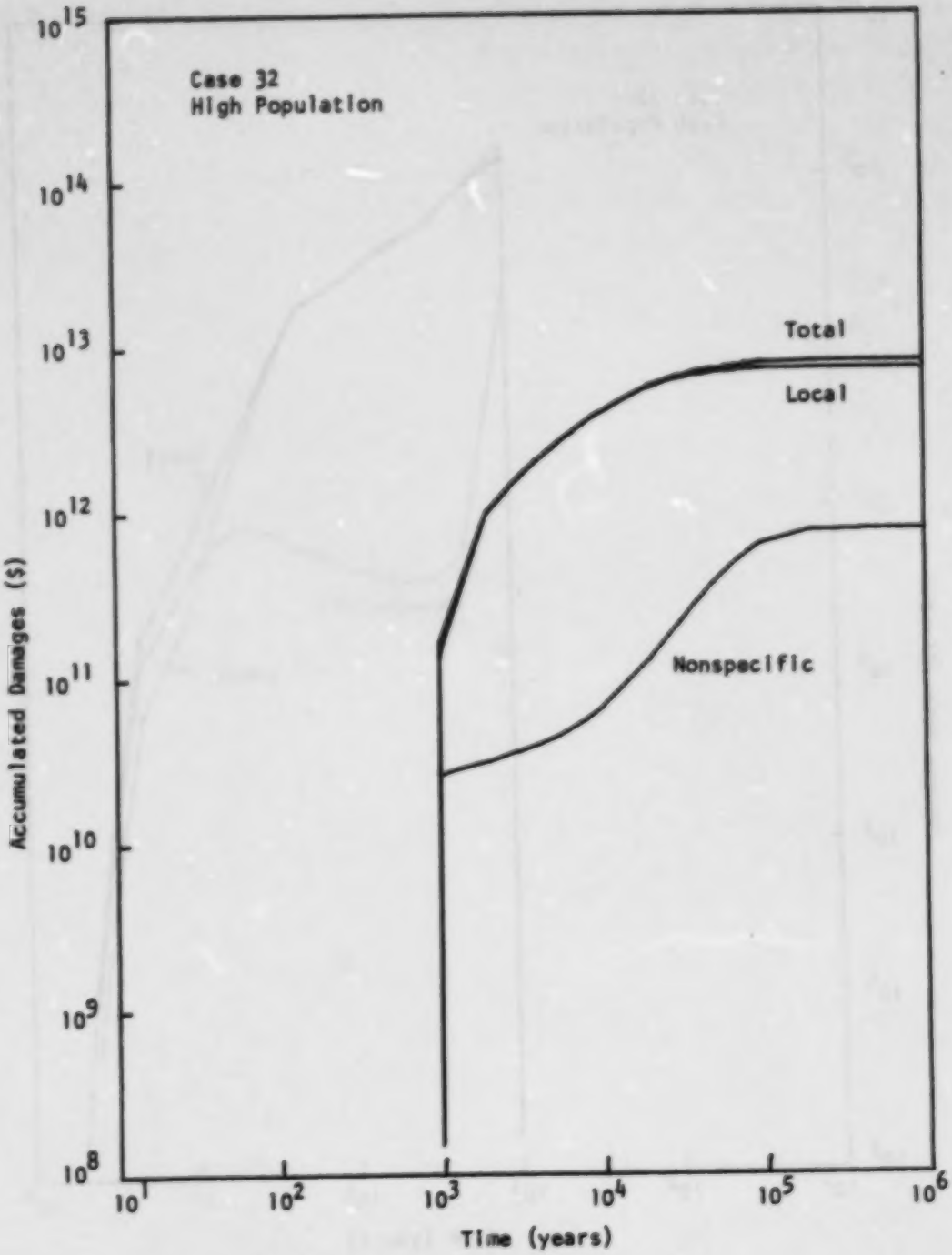


Figure 9-4. Accumulated damage following volcanic release to air at 1000 y.

the total with time is due to radiodecay and environmental decay following the initial dispersion. In this study a token value is used for environmental decay, corresponding to an environmental half-time of 30,000 y. It is expected that this is a greatly overstated persistence but data is not available at this time to justify shorter nuclide-dependent half-times. Case 33, shown in Figs. 9-5 and 9-6, assumes an environmental decay constant increased by a factor of 100 (environmental half-time of 300 y) for comparison. The much steeper drop-off with time is apparent. From the summary of integrated damages in Table 9-2, it may be seen that the factor of 100 change in environmental decay, reduces integrated damages by a factor of 20.

Figure 9-7 shows the total damage rates following volcanic releases at 1000 y, 10,000 y, and 100,000 y respectively. There is an envelope described by the maximums at the times of the individual release times; this envelope reflects the radiodecay of the waste inventory. The curve for releases at 1000 y and 10,000 y fall away from the envelope of maximums due to the token environmental decay calculated. The curve for Case 33 shows the much sharper drop-off for the increased environmental decay rate. From the plots in Fig. 9-7, approximate responses could be sketched for other assumed times of event occurrence and for other environmental decay rates.

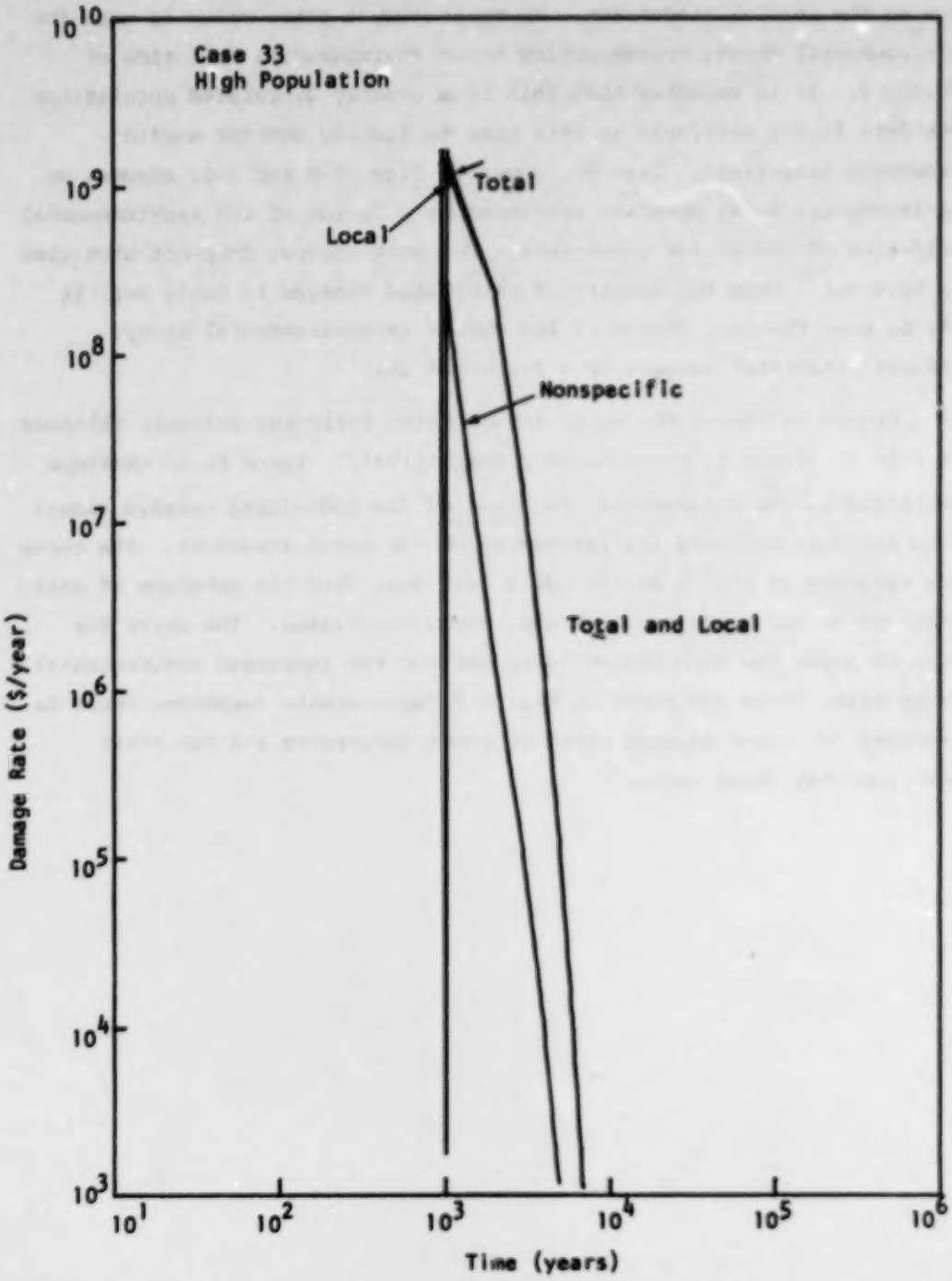


Figure 9-5. Damage rate following volcanic release to air at 1000 y and environmental decay rate increased by factor of 100.

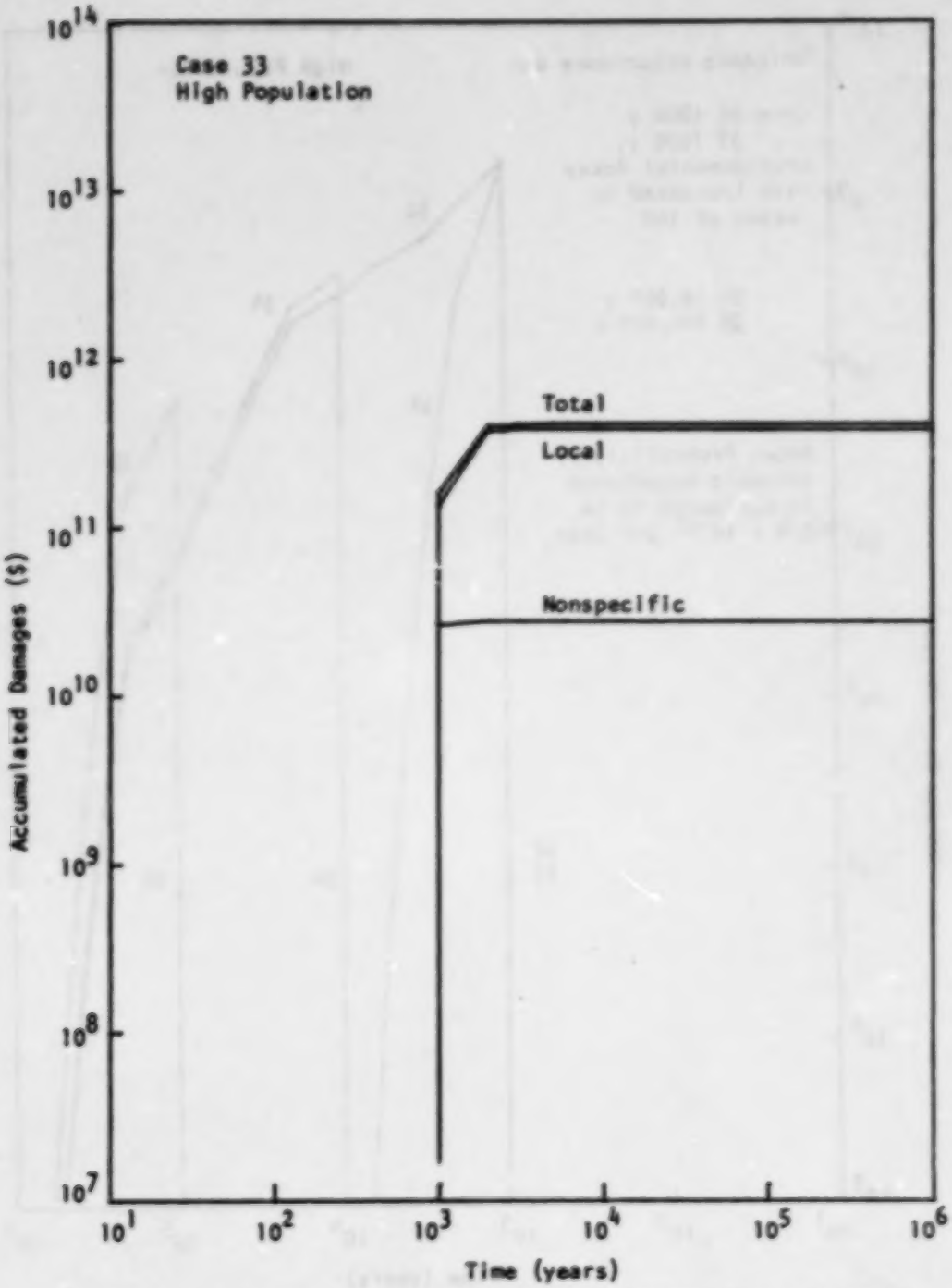


Figure 9-6. Accumulated damages following volcanic release to air at 1000 y and environmental decay rate increased by factor of 100.

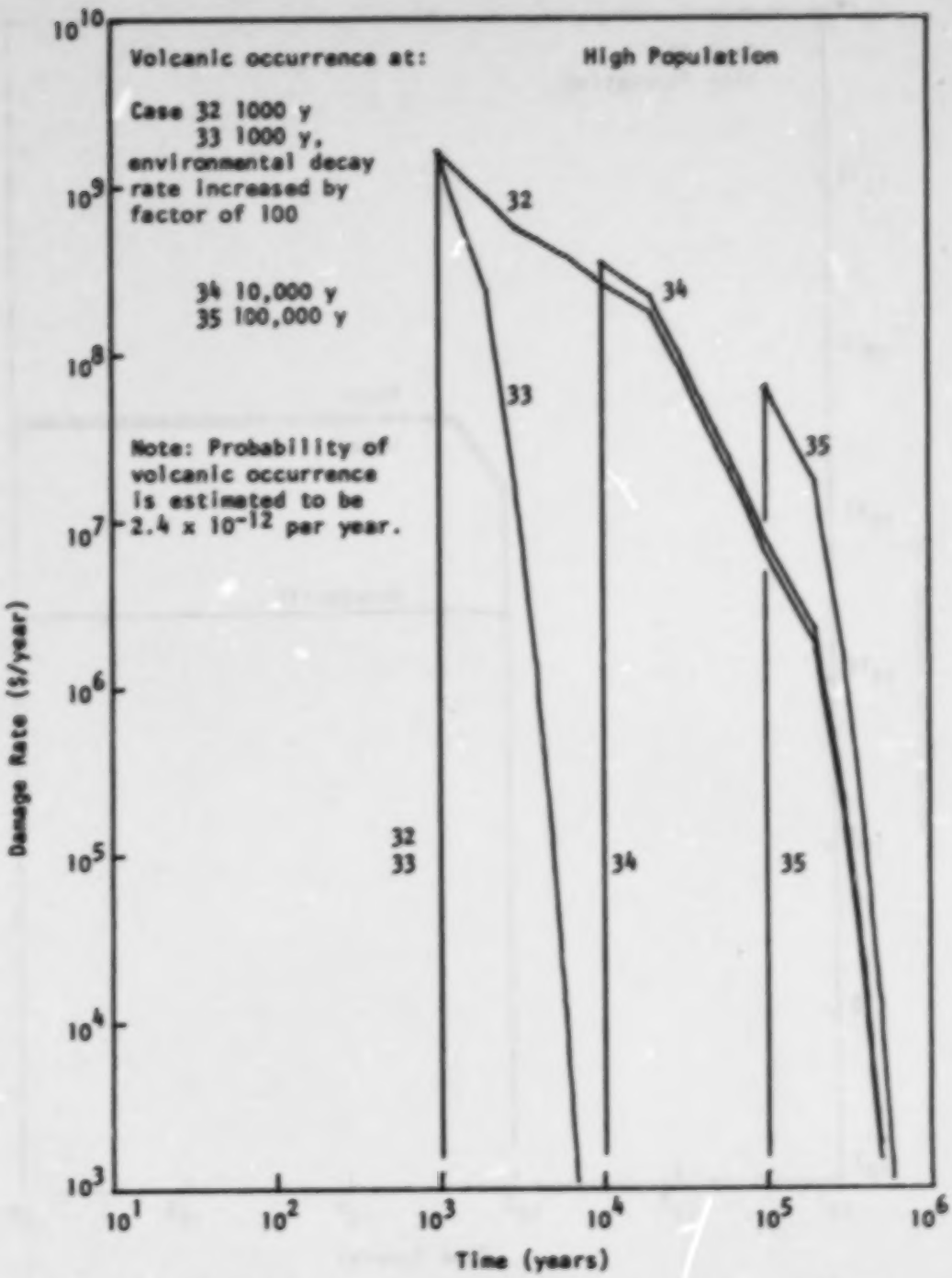


Figure 9-7. Total damage rates following volcanic release to air at various times.

CHAPTER 10

DISCUSSION OF RESULTS

The previous two chapters present and discuss implementation and results obtained for a base case (Chapter 8) and for a series of other cases for discrete release events (Chapter 9). This chapter provides additional discussion to extend and interpret those results for terminal storage in a bedded salt reference repository.

A. BASE CASE

The base case described in Chapter 8 uses dose rates calculated by AMRAW-A run in the probabilistic mode, in which several geologic disturbance events are simultaneously considered. The results obtained with AMRAW-B do not represent predictions of actual damage costs. The geologic events have very low probabilities for occurrence and are therefore unlikely to occur during the time period studied: one million years. Allowing the events to partially "occur" via the probabilistic method provides a basis for risk comparisons between alternative repository sites, types of geologic formations, fuel cycles and waste forms. Also the method allows ranking the various release scenarios according to relative contributions to long term risk and helps to identify areas of study requiring additional attention for minimizing risk. The present status of available geologic data results in large uncertainties in estimates of probabilities which affects the calculated risk, but doesn't preclude relative evaluation of various management options. Further development of predictive geology may be able to apply modern concepts of global tectonic movement to show zero probability of volcanic eruption for a period of time greater than the one million year study period used here instead of the constant probability used from the time the repository is closed.

The Economic Model collects consequences from each zone into a total and adds the nonspecific category. This obtains total damage values which may readily be compared for various options. During the last 300,000 y of the 10^6 y range of calculations, Np appears in ground water in Zone 2 (see Fig. 8-7) and has a significant effect on integrated totals. It should be noted that these results assumed a ground water velocity 6 times the estimated velocity, to cover uncertainty. If a value of only 4 or less were used instead of 6, Np would not appear in ground water at a discharge distance of 10 km until after 10^6 y. For this reason, it is of interest to also examine totals integrated over the first 700,000 y, which precedes the Np ground water contribution. Table 10-1 summarizes calculated damages, by nuclide and total, for integration over 700,000 y as well as 10^6 y. This table lists damages as calculated by AMRAW-B (before attribution) and after attribution to

Table 10-1. Comparison of Total Damages for Base Case Before and After Attribution to Precursors for Two Time Integration[a] Ranges

Decay Group	Nuclide	Integration for 10^6 y		Integration for 7×10^5 y	
		Before Attribution, $	After Attribution, $	Before Attribution, $	After Attribution, $
1	Cm-244	9.58E+2[b]	1.74E+5	9.58E+2	1.74E+5
	Pu-240	3.71E+5	1.98E+5	3.71E+5	1.98E+5
2	Pu-241	5.77E+2	5.66E+6	5.77E+2	1.57E+5
	Am-241	8.99E+4	1.32E+8	8.99E+4	3.63E+6
	Np-237	6.82E+8	5.70E+8	3.02E+6	1.54E+7
	Th-229	1.77E+7		1.14E+7	
	Ra-225	7.16E+6		4.61E+6	
3	Am-242m	2.17E+2	6.26E+6	2.17E+2	5.37E+6
	Cm-242	1.05E+1	2.10E-2	1.05E+1	2.10E-2
	Pu-238	8.76E+2	5.89E+7	8.76E+2	5.06E+7
	Th-230	1.13E+6		9.71E+5	
	Ra-226	6.31E+7		5.42E+7	
	Pb-210	9.85E+5		8.45E+5	
4	Am-243	1.03E+6	3.30E+6	1.03E+6	3.30E+6
	Np-239	1.53E+4	0.0	1.53E+4	0.0
	Pu-239	2.47E+6	2.22E+5	2.47E+6	2.22E+5
5	Sr-90	4.18E+3	4.21E+3	4.18E+3	4.21E+3
	Y-90	2.78E+1		2.78E+1	
6	Zr-93	2.51E+3	3.46E+4	1.82E+3	2.50E+4
	Nb-93m	3.21E+4		2.32E+4	
7	Tc-99	4.82E+8	4.82E+8	4.25E+8	4.25E+8
8	I-129	4.58E+3	4.58E+3	2.90E+3	2.90E+3
9	Cs-135	2.56E+4	2.56E+4	1.79E+4	1.79E+4
10	Cs-137	1.17E+3	1.17E+3	1.17E+3	1.17E+3
11	C-14	3.16E+1	3.16E+1	3.16E+1	3.16E+1
	TOTAL	1.26E+9	1.26E+9	5.04E+8	5.04E+8

[a]Data from Case 48, high population projection.

[b]9.58E+2 denotes 9.58×10^2.

precursors by the scheme described in Section 8.D. Table 10-2 presents the accumulations by elements for the shorter integration range, corresponding to the earlier Table 8-12 for 10^6 y. Shortening the integration range reduces the Np share of damages from 45% to 3%, reduces Am from 11 to 2.4% (Am-241 is the parent of Np-237), and correspondingly doubles the relative contributions by Tc and Pu. Conclusions are therefore sensitive to the time range considered.

Most of the results presented here are for the high population, though some values are tabulated for low population. While the total high population is 3.5 times the low projection (and 5 times the 1970 population), the total damages calculated do not vary linearly with total population. This is because changes in population are not at a uniform factor for various zones, and the nonspecific category is limited by irrigation water availability and grazing land capacity instead of being population dependent. If a different population is assumed by the same factor in each zone, the local category of damages can be adjusted linearly.

There is uncertainty in the incidence rate of serious genetic effects, taken here to be 200 per 10^6 man-rem. Serious genetic effects are treated as being equivalent to death for assessment purposes. Genetic effects are accrued to the time the dose is incurred instead of accounting for expected lags (see Appendix A). This does not effect total damages calculated but has some effect on the time distribution of damages. On these bases, genetic effects account for about 6% of the total damages.

Total damages vary linearly with the dollar value used for risk of death. If it develops that genetic effects should be evaluated on a different basis, the somatic and genetic components can be adjusted accordingly.

Use of zero discounting gives equal weighting for the present value of damages occurring at any time during the time range evaluated. This tends to overwhelm early contributions by integrations over the later portions of a 10^6 y range. Further study of discount philosophy should be done.

Table 10-2. Attribution of Base Case Total Damages Integrated Over 700,000 y to Elements Initially in Inventory

Element	Total Damages	Percent of Total
Fission and Activation Products:		
C	3.16+1[a]	6×10^{-6}
Sr	4.21+3	8×10^{-4}
Zr	2.50+4	5×10^{-3}
Tc	4.25+8	84.33
I	2.90+3	6×10^{-4}
Cs	1.91+4	4×10^{-3}
Subtotal	4.25+8	84.33
Actinides:		
Np	1.54+7	3.07
Pu	5.12+7	10.16
Am	1.23+7	2.44
Cm	1.74+5	0.03
Subtotal	7.91+7	15.69
TOTAL	5.04+8	100.00

[a] 3.16+1 denotes 3.16×10^{1}

Table 10-3. Summary of Marginal Damages Based Upon Several Parameters

Parameter	Quantity	Unit	10^6 y Integrated Damages[a]	
			$/Unit	Deaths/Unit
Mass of waste radionuclides				
All nuclides	6.4×10^9	gram	0.20	7.5×10^{-7}
25 selected nuclides	8.0×10^8	gram	1.57	6.0×10^{-6}
Reactor fuel represented	187,000	metric ton	6,740.	0.026
Waste canisters[b]	62,500	canisters	20,160.	0.077
Reactor-years	7,850	reactor-year	160,500.	0.62
Electrical energy represented	4.8×10^{13}	kw-hr	2.6×10^{-5} (0.026 mill/ kw-hr)	1.0×10^{-10}

[a]Total 10^6 y integrated damages: $\$1.26 \times 10^9$, 4,840 deaths.

[b]Canister capacity: waste from 3 metric tons of spent fuel.

While the calculated damages from AMRAW-B represent a comparison index for different waste management alternatives and do not represent predictions of absolute damage costs, it is of some interest in gaining a perspective view to determine marginal damages on various bases using the calculated total damages. The base case total damages of $1.26 x 10^9 and 4,840 deaths represent average annual rates of $1,260 and 0.0005 deaths. The reference repository inventory assumed here is the high-level radioactive waste from reprocessing of 187,000 metric tons (MT) of spent fuel on the basis of 33,000 MWd/MT burnup. Burnup is defined in terms of thermal energy. Assuming a thermal efficiency of 0.325, the electrical energy represented by the 187,000 MT of fuel is

$$187{,}000 \times 33{,}000 \times 0.325 \times 24 \times 10^3 = 4.82 \times 10^{13} \text{ kw-hr.} \qquad (10\text{-}1)$$

Assuming the average reactor has an electrical generating capacity of 1000 MW(e) and operates with a capacity factor of 0.70, 1 reactor-y is 1000 x 0.70 = 700 MW(e)-y of energy. The number of reactor-years represented by the 187,000 MT of fuel becomes

$$\frac{187{,}000 \times 33{,}000 \times 0.325}{365 \times 700} = 7{,}850. \text{ reactor-y.} \qquad (10\text{-}2)$$

Table 10-3 summarizes marginal damages based upon several parameters, including kw-hr and reactor-y. Referenced to electrical energy produced, the indicated marginal damages for the base case are 0.026 mill/kw-hr; this is only 0.13% of total cost of nuclear generated electricity, assuming 20 mills/kw-hr.

B. OTHER CASES

The leaching incident initiated by offset faulting at 100 y (Case 50) results in only 5 nuclides appearing in ground water at a distance of 10 km within 10^6 y. When attributed to precursors present at the time the terminal storage phase begins, 7 nuclides are involved, as listed in Table 10-4. When accumulated to elements (Table 10-5), damages are attributed primarily to Tc, Np, and Am, with some contribution from Pu. The dominance by Np (71% of total damages) is due to breakthrough after 800,000 y. As discussed in the previous section, shortening the time range of integration or use of a less conservative value for ground water velocity eliminates the Np-237 and Np-239 contributions (Table 10-4), and virtually all damages then accrue to Tc. Tc is important in ground water because of: 1) its large concentration in the initial waste inventory (2.4% of the total waste nuclide mass and 19% of the 25 selected nuclide mass), and 2) movement in water without retardation due to zero estimated sorption. The leaching incident scenario has an estimated probability of occurrence of 1.4×10^{-7} per year.

A volcanic explosion release to air occurring at 1000 y (Case 32) indicates severe levels of damages for such an event. However, the probability of occurrence is estimated to be 2.4×10^{-12} per year (only 2.4×10^{-6} probability of occurring within a 10^6 y period). Table 10-4 includes the damages, by nuclide, before and after attribution to precursors and Table 10-5 includes the corresponding attribution to elements. For dispersal via the atmosphere, Tc is a minor contributor and calculated damages are dominated by Am followed by Pu. The high damages for the volcanic discrete event are based upon a token value of environmental decay constant (environmental half-time of 30,000 y). An increase in the value for the environmental decay constant by a factor of 100 (Case 33 in Table 9-2) reduces the calculated damages by a factor of 20. Better data regarding environmental persistence of radionuclides is needed for evaluation of such high consequence-low probability events.

Later occurrence of the volcanic events reduces the damages. Occurrence at 100,000 y (Case 35) reduces the subsequent impact compared to occurrence at 1000 y (Case 32) by 40% for the low population projection and by 69% for the high population (Table 9-2).

Table 10-4. Total Damages Before and After Attribution to Precursors for Discrete Release Events

Decay Group	Nuclide	Leach Incident Total Damages[a]		Volcanic Explosion Total Damages[b]	
		Before Attribution, $	After Attribution, $	Before Attribution, $	After Attribution, $
1	Cm-244			9.76E-3	6.82E+11
	Pu-240			1.46E+12	7.78E+11
2	Pu-241		4.46E+9[c]	1.90E+9	2.84E+10
	Am-241		1.04E+11	5.94E+11	6.06E+11
	Np-237	5.57E+11	4.49E+11	8.47E+10	1.62E+11
	Th-229			9.02E+10	
	Ra-225			2.60E+10	
3	Am-242m			1.36E+9	7.79E+10
	Cm-242			6.88E+7	1.38E+5
	Pu-238			2.23E+9	7.21E+11
	Th-230			1.97E+10	
	Ra-226			7.63E+11	
	Pb-210			1.21E+10	
4	Am-243		9.15E+3	3.39E+12	4.93E+12
	Np-239	9.15E+3	0.0	7.71E+10	0.0
	Pu-239			1.60E+12	1.44E+11
5	Sr-90			3.44E+3	3.46E+3
	Y-90			2.27E+1	
6	Zr-93			5.04E+7	6.87E+8
	Nb-93m			6.37E+8	
7	Tc-99	7.81E+10	7.81E+10	1.57E+10	1.57E+10
8	I-129	4.18E+5	4.18E+5	9.81E+4	9.81E+4
9	Cs-135			5.06E+8	5.06E+8
10	Cs-137			3.87E+3	3.87E+3
11	C-14	1.87E+4	1.87E+4	5.35E+7	5.35E+7
	TOTAL	6.35E+11	6.35E+11	8.15E+12	8.15E+12

[a]Leach incident commencing at 100 y: Case 50, high population projection.

[b]Volcanic explosion release to air at 1000 y: Case 32, high population projection.

[c]4.46E+9 denotes 4.46×10^9.

Table 10-5. Attribution of Total Damages to Elements Initially in Inventory for Discrete Release Events

Element	Leach Incident[a]		Volcanic Explosion[b]	
	Total Damages, $	Percent of Total	Total Damages, $	Percent of Total
Fission and Activation Products:				
C	1.87×10^{4}	3×10^{-6}	5.35×10^{7}	6×10^{-4}
Sr			3.46×10^{3}	4×10^{-8}
Zr			6.87×10^{8}	8×10^{-3}
Tc	7.81×10^{10}	12.3	1.57×10^{10}	0.2
I	4.18×10^{5}	6×10^{-5}	9.81×10^{4}	1×10^{-6}
Cs			5.06×10^{8}	6×10^{-3}
Subtotal	7.81×10^{10}		1.69×10^{10}	
Actinides:				
Np	4.49×10^{11}	70.7	1.62×10^{11}	2.0
Pu	4.46×10^{9}	0.7	1.67×10^{12}	20.5
Am	1.04×10^{11}	16.4	5.61×10^{12}	68.9
Cm			6.82×10^{11}	8.4
Subtotal	5.57×10^{11}		8.12×10^{12}	
TOTAL	6.35×10^{11}	100.	8.15×10^{12}	100.

[a]Leach incident commencing at 100 y: Case 50, high population projection.

[b]Volcanic explosion release to air at 1000 y: Case 32, high population projection.

C. MOST SIGNIFICANT RADIONUCLIDES AND ELEMENTS

The 25 radionuclides used in this study were screened from the several hundred initially present in the waste. The screening method [Lo74b], described in Vol. I, Section 4.B., selected the most significant nuclides over the full 10^6 y time range on the basis of a hazard measure defined as the Curies of a given radionuclide in a quantity of waste (such as from one metric ton of fuel) divided by the corresponding Radiation Concentration Guide (RCG) value [CFR20]. The screening does not consider behavior in movements through the geosphere and biosphere. After running the selected nuclides through AMRAW-A, ranking of nuclides by importance was done according to environmental concentrations and dose rates in various zones at various times (see Chapter 8 in Vol. II). Subsequently, AMRAW-B considers population projections in each zone and provides summations of damages over the whole region and over the full time range. In this chapter and in Chapters 8 and 9, relative importance of nuclide is discussed for the several demonstration cases and various bases of comparison.

The 5 most significant nuclides and elements obtained by analyses discussed previously are summarized in Table 10-6 for the base case and in Table 10-7 for other cases. In all instances listed, the top 5 represent at least 95% (and in most instances 99% or more) of the total damages from all 25 selected nuclides (15 elements). It can be noted that the nuclides included and their ranking depend upon the basis of comparison. For example, in Table 10-6, Ra-226 is prominent when ranking is based upon integrated damages over the time range. However, if a management decision is to be made to reduce the impact from Ra-226, it is the precursors Am-242m and more particularly Pu-238 which must be controlled in the initial repository inventory. Hence, the most significant nuclides after attribution to precursors do not include Ra-226 but include isotopes which result in subsequent production of Ra-226. Similarly, with present technology, management decisions can be exercised only with regard to chemical elements and not by specific nuclides. The ranking of elements after accumulation of the significant isotopes is therefore of importance.

Table 10-6. Summary of Most Significant Radionuclides and Elements on Various Bases for Base Case[a]

	Basis of Ranking		
	Damages Integrated Through 10^6 y, $	Damages Integrated Through 7×10^5 y, $	Maximum Damage Rate, $/y
Before Attribution to Precursors:			
	Np-237[b]	Tc-99[c]	Np-237[d]
	Tc-99	Ra-226	Tc-99
	Ra-226	Th-229	Ra-226
	Th-229	Ra-225	Sr-90
	Ra-225	Np-237	Am-243
% of Total	99.6	98.9	(does not apply)
After Attribution to Precursors:			
	Np-237[c]	Tc-99[c]	
	Tc-99	Pu-238	
	Am-241	Np-237	
	Pu-238	Am-242m	
	Am-242m	Am-241	
% of Total	99.1	99.2	
Elements:			
	Np[e]	Tc[f]	
	Tc	Pu	
	Am	Np	
	Pu	Am	
	Cm (0.01%)	Cm (0.03%)	
% of Total	100	100	

[a]The 5 nuclides or elements contributing the greatest damages or damage rates are listed in sequence beginning with the highest, from Case 48.

[b]Reference: Table 8-6, 8-9, or 10-2.

[c]Reference: Table 10-2.

[d]Reference: Table 8-8.

[e]Reference: Table 8-12.

[f]Reference: Table 10-3.

Table 10-7. Summary of Most Significant Radionuclides and Elements Based Upon Discrete Release Events[a]

	Basis of Ranking	
	Leach Incident[b] Damages Integrated Through 10^6 y, $	Volcanic Explosion[c] Damages Integrated Through 10^6 y, $
Before Attribution to Precursors:		
	Np-237[d]	Am-243[d]
	Tc-99	Pu-239
	I-129	Pu-240
	C-14	Ra-226
	Np-239	Am-241
Percent of Total	100	96.7
After Attribution to Precursors:		
	Np-237[d]	Am-243[d]
	Am-241	Pu-240
	Tc-99	Pu-238
	Pu-241	Cm-244
	I-129 (7×10^{-5}%)	Am-241
Percent of Total	100	94.7
Elements:		
	Np[e]	Am[e]
	Am	Pu
	Tc	Cm
	Pu	Np
	--	Tc (0.2%)
Percent of Total	100	100

[a]The 5 nuclides or elements contributing the greatest damages are listed in sequence beginning with the highest.

[b]Case 50.

[c]Case 32.

[d]Reference: Table 10-4.

[e]Reference: Table 10-5.

The time range over which damages are integrated strongly effects the relative importance of nuclides. Table 10-6 indicates that if integration is only through 700,000 y instead of 10^6 y, the importance of Np drops due to elimination of the breakthrough of Np in ground water after 700,000 y. This also illustrates a strong dependence upon ground water velocity, sorption properties (which effect retardation of nuclide movement), and distances to ground water discharge. If integration were restricted to times less than 10,000 y or if a non-zero discount were used, the relatively large contributions by Tc would be omitted (see Fig. 8-7) and Sr-90 and Cs-137 would move up in importance. Where ground water is important, Tc becomes prominent in a relative way because it moves readily with ground water compared with other nuclides which are greatly retarded. For surface dispersion as with a volcanic explosion (Table 10-7), the relative importance of Tc drops to a low level.

The lists of 5 most significant nuclides in Tables 10-6 and 10-7 include 13 of the 25 selected nuclides before attribution. When attributed to precursors, 7 of the 13 drop out and 4 others are added. Hence, two-thirds of the selected nuclides are among the most significant on one or more bases. When elements are considered (Tables 10-6 and 10-7), virtually all of the calculated damages for the base case and the leach incident case may be attributed to only 4 elements: Am, Np, Pu, and Tc. Cm makes a slight contribution. For a release to air as with volcanism, Tc drops in relative importance and Cm moves up. Cm produces 8.4% of the damages for a volcanic event occurring at 1000 y. However, a volcanic explosion later than 100,000 y would have insignificant contributions from Cm due to decay of both Cm-244 and the daughter Pu-240.

The emergence of Am, Np, Pu, and Tc as the major contributors to long term potential environmental impact suggests that management decisions should aim to minimize their presence in a repository inventory. Separation of actinides and Tc from spent fuel and transmutation in a reactor therefore can significantly reduce the risk from terminal storage. This study has not examined the risk associated with reprocessing and the added handling for recycling through reactors (see [Cr77]). It is of interest to note that absorption of one or more neutrons by Tc-99 produce short half-life isotopes of Tc which quickly decay to <u>stable</u> Ru isotopes.

APPENDIX A

SUPPLEMENTARY GENETIC RISK DISCUSSION
(W. D. SCHULZE)

Genetic risk presents a special problem in that the equilibrium level of genetic damage according to the BEIR report [NAS72] might not be reached until 900 y after an increase in the continuous exposure level. The other categories consisting of cancer mortality by site accrue in one generation. In this analysis, it is assumed that a serious genetic effect may be equated to a death for damage evaluation purposes.

A zero discount rate is assumed in this study. If a non-zero discount rate becomes justified, additional discounting arises due to deferred genetic effects. To demonstrate how discounting affects the assessment of genetic damages, some understanding of the approach to the equilibrium level of genetic risk as developed in the BEIR report must be included. If risk of increased death/10^6 population (per rem to individuals) is denoted by R and dose in rems to individuals by m, then a simple asymptotic approach to the equilibrium level of increased health risk from genetic damage is approximated by the differential equation

$$\dot{R}(t) = c_o m - c_1 R(t) \qquad \text{(A-1)}$$

where m is assumed constant over time, t. The solution takes the form

$$R(t) = \frac{c_o}{c_1}\left(1 - e^{-c_1 t}\right)m. \qquad \text{(A-2)}$$

It is assumed that $c_o > 0$ and $c_1 > 0$ because exposure to ionizing radiation incurs genetic damage ($c_o > 0$) and that some of this damage is not inherited if death occurs prior to reproductive age, so risk "decays" at rate c_1. It is assumed as suggested in the BEIR report that equilibrium risk is approached in thirty generations (900 y). This equilibrium level has a range due to uncertainty but the more likely value is approximately 200 serious genetic effects per 10^6 population per rem. Assuming that 20% of the serious genetic effects develop in the first generation (30 y), the curve represented by Eq. A-2 is fit through that point by determining

c_1:

$$\left(1 - e^{-c_1 t}\right) = \left(1 - e^{-30c_1}\right) = 0.20 \qquad \text{(A-3)}$$

$$c_1 = 0.0074$$

Then, from $c_o/c_1 = 200$, $c_o = 1.48$, and Eq. A-2 becomes

$$R(t) = 200\left(1 - e^{-0.0074t}\right)m \qquad \text{(A-4)}$$

For higher or lower risk estimates, c_o scales up or down. The resulting approach to equilibrium risk is shown in Figure A-1 following a 1-rem increase in continuous population exposure. This curve approaches to within 0.15% of the equilibrium value by 900 y.

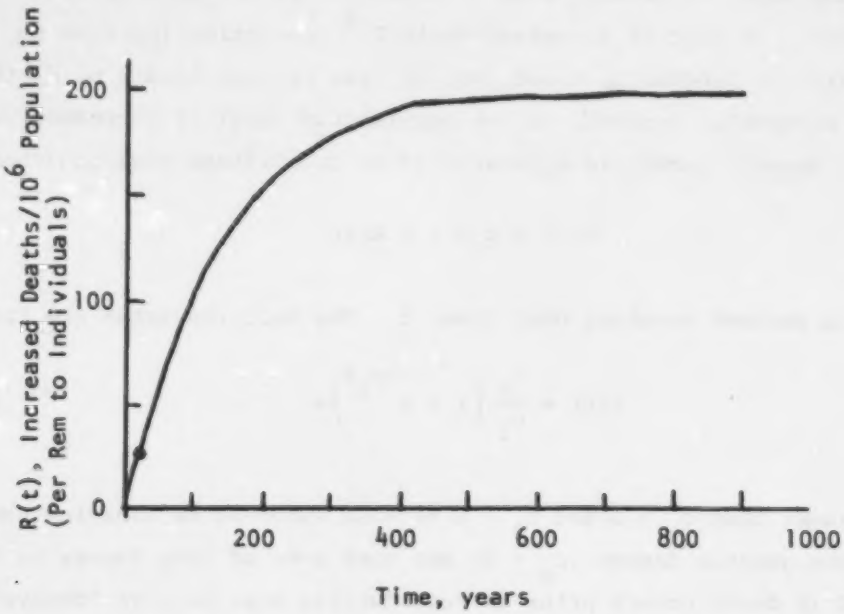


Figure A-1. Genetic approach to equilibrium.

Note also that the equilibrium solution ($t = \infty$) is

$$R_e = c_o/c_1 = 200, \quad m = 1. \qquad \text{(A-5)}$$

This formulation is only illustrative since different components of genetic risk have substantially different time horizons and the exponential approach chosen is only an approximation. It can be shown that the discounted present value of future genetic damage can be approximated by the simple formula

$$\frac{\$\ \text{Genetic Risk}}{\text{rem}} = \left(\frac{c_o}{c_1 + r}\right)\left(\frac{\$260 \times 10^3}{10^6\ \text{population}}\right) \qquad \text{(A-6)}$$

where r is the interest rate, the cost of excess risk per expected death is $\$260 \times 10^3$ and this is divided by 10^6 to yield \$/rem. The interpretation of this formula is that incremental damages ($c_o \times \$260{,}000 \div 10^6$) are discounted at the sum of the rate of discount and the decay rate of genetic damage, $r + c_1$.

If v is the unit productive value to society of benefits offsetting exposure in rems (m) and z is the dollar cost of excess risk per genetic death, the present value of discounted net benefits over the time horizon, T, represented by the following can be maximized:

$$\int_o^T e^{-rt}[v \cdot m - z \cdot R]\, dt, \qquad \text{(A-7)}$$

where net benefits are the total value of allowing exposure, $v \cdot m$, minus the dollar cost of excess $z \cdot R$. This optimization problem is constrained by the differential equation described above for R(t) and has as a necessary condition for an optimum that[a]

$$v = \frac{c_o z}{c_1 + r}\left[1 - e^{-(c_1 + r)(T - t)}\right]. \qquad \text{(A-8)}$$

Since reasonable time horizons (T - t) for genetic risk are in the tens of thousands of years, the term

$$e^{-(c_1 + r)(T - t)}$$

[a]The demonstration of this result requires use of optimal control theory.

can be ignored since it is assumed $(c_1 + r) > 0$. Thus, the appropriate value (v) to be placed on genetic risk is verified. Substituting the estimates for c_o and c_1 and $z = 260{,}000 \div 10^6$ into Eq. A-8 yields

$$v = \frac{\$\ \text{Genetic Risk}}{\text{rem}} = \frac{1.48 \times 0.26}{0.0074 + r} = \frac{0.38}{0.0074 + r}. \qquad \text{(A-9)}$$

If $r = 0$ and a zero value for the interest rate of social rate of discount on future generations is assumed, then v = \$52, which is the value derived from the BEIR equilibrium genetic risk by using Thaler and Rosen's [T&75] estimate of \$260/year for an increase in risk of 10^{-3} (see Table 5-6). If, on the other hand, a typical real discount rate of six percent (above the rate of inflation) is used, then $r = .06$ and v =\$5.60 Thus, the choice of discount rate is of critical importance in evaluating genetic risk.

To obtain a total discounted value for genetic risk to the base year when the repository is sealed (year 0), the genetic damage as defined above must be discounted further using the following formula

$$\int_o^{10^6} e^{-rt}\left[\sum_{k=1}^{8} \frac{0.38 m_k(t)}{0.0074 + r}\right] dt$$

where $m_k(t)$ is the aggregate population dose for Zone k (8 zones assumed) in time t in man-rems as obtained from the AMRAW-A code.

Present programming in AMRAW-B handles genetic effects in the same manner as cancers; the equilibrium incidence conservatively accrues to the time increment in which dose is calculated. If a non-zero discount rate becomes justified, it may be appropriate to add provisions for the additional discounting due to deferred effects, as discussed above.

APPENDIX B

SAMPLE DOSE RATE OUTPUT FROM AMRAW-A

Sample output for the full run base case for terminal storage phase, Case No. 48, are presented in this appendix. This type of output from AMRAW-A is processed through the auxiliary program, COMPRESS, for use in AMRAW-B.

1. Table B-1. Average Annual Local Dose to Individual in Zone 1, from Ra-226, in Millirems/Year.
2. Table B-2. Average Annual Nonspecific Dose to Population from Ra-226, in Man-rems/Year.

Appendix B
Table B-1.

** AVERAGE ANNUAL LOCAL DOSE TO INDIVIDUAL, MANIL, IN MILLIREMS/YEAR

ZONE= 1... NUCLIDE= RA-226 K= 12

TIME	TOT BODY	GI TRACT	GONADS	LIVER	LUNGS	MARROW	BONE	THYROID
0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40.	1.42E-13	6.24E-16	1.42E-13	5.72E-16	4.13E-13	1.68E-12	1.68E-12	7.25E-16
50.	2.43E-13	1.42E-15	2.44E-13	1.37E-15	7.05E-13	2.87E-12	2.87E-12	1.75E-15
60.	3.82E-13	2.53E-15	3.83E-13	2.49E-15	1.11E-12	4.51E-12	4.51E-12	3.17E-15
70.	5.68E-13	4.04E-15	5.69E-13	4.02E-15	1.65E-12	6.69E-12	6.69E-12	5.12E-15
80.	8.12E-13	6.04E-15	8.14E-13	6.05E-15	2.35E-12	9.56E-12	9.56E-12	7.71E-15
90.	1.12E-12	8.63E-15	1.13E-12	8.67E-15	3.25E-12	1.32E-11	1.32E-11	1.11E-14
100.	1.52E-12	1.19E-14	1.52E-12	1.20E-14	4.39E-12	1.78E-11	1.78E-11	1.53E-14
200.	9.15E-12	7.89E-14	9.18E-12	8.03E-14	2.65E-11	1.08E-10	1.08E-10	1.03E-13
300.	4.10E-11	3.63E-13	4.12E-11	3.70E-13	1.19E-10	4.82E-10	4.82E-10	4.73E-13
400.	1.20E-10	1.07E-12	1.20E-10	1.10E-12	3.46E-10	1.41E-09	1.41E-09	1.40E-12
500.	2.69E-10	2.43E-12	2.70E-10	2.48E-12	7.78E-10	3.16E-09	3.16E-09	3.17E-12
600.	5.14E-10	4.65E-12	5.15E-10	4.76E-12	1.49E-09	6.04E-09	6.04E-09	6.08E-12
700.	8.76E-10	7.97E-12	8.79E-10	8.15E-12	2.53E-09	1.03E-08	1.03E-08	1.04E-11
800.	1.38E-09	1.25E-11	1.38E-09	1.28E-11	3.98E-09	1.62E-08	1.62E-08	1.64E-11
900.	2.03E-09	1.86E-11	2.04E-09	1.90E-11	5.88E-09	2.39E-08	2.39E-08	2.43E-11
1000.	2.87E-09	2.63E-11	2.88E-09	2.69E-11	8.31E-09	3.38E-08	3.38E-08	3.43E-11
2000.	1.61E-08	1.48E-10	1.62E-08	1.52E-10	4.66E-08	1.89E-07	1.89E-07	1.94E-10
3000.	5.88E-08	5.42E-10	5.90E-08	5.55E-10	1.70E-07	6.91E-07	6.91E-07	7.09E-10
4000.	1.37E-07	1.26E-09	1.37E-07	1.29E-09	3.95E-07	1.60E-06	1.60E-06	1.65E-09
5000.	2.52E-07	2.32E-09	2.52E-07	2.38E-09	7.27E-07	2.96E-06	2.96E-06	3.04E-09
6000.	4.04E-07	3.74E-09	4.06E-07	3.83E-09	1.17E-06	4.75E-06	4.75E-06	4.89E-09
7000.	5.94E-07	5.49E-09	5.96E-07	5.62E-09	1.72E-06	6.98E-06	6.98E-06	7.18E-09
8000.	8.19E-07	7.57E-09	8.21E-07	7.75E-09	2.37E-06	9.62E-06	9.62E-06	9.90E-09
9000.	1.08E-06	9.98E-09	1.08E-06	1.02E-08	3.12E-06	1.27E-05	1.27E-05	1.31E-08
10000.	1.38E-06	1.27E-08	1.38E-06	1.30E-08	3.98E-06	1.62E-05	1.62E-05	1.67E-08
20000.	4.85E-06	4.49E-08	4.87E-06	4.60E-08	1.40E-05	5.70E-05	5.70E-05	5.87E-08
30000.	1.15E-05	1.06E-07	1.15E-05	1.09E-07	3.32E-05	1.35E-04	1.35E-04	1.39E-07
40000.	1.91E-05	1.77E-07	1.92E-05	1.81E-07	5.52E-05	2.24E-04	2.24E-04	2.31E-07
50000.	2.66E-05	2.46E-07	2.67E-05	2.52E-07	7.69E-05	3.13E-04	3.13E-04	3.22E-07
60000.	3.36E-05	3.11E-07	3.37E-05	3.19E-07	9.72E-05	3.95E-04	3.95E-04	4.07E-07
70000.	4.01E-05	3.71E-07	4.03E-05	3.80E-07	1.16E-04	4.71E-04	4.71E-04	4.86E-07
80000.	4.59E-05	4.25E-07	4.60E-05	4.35E-07	1.33E-04	5.39E-04	5.39E-04	5.56E-07
90000.	5.09E-05	4.71E-07	5.11E-05	4.83E-07	1.47E-04	5.98E-04	5.98E-04	6.17E-07
100000.	5.53E-05	5.12E-07	5.55E-05	5.24E-07	1.60E-04	6.50E-04	6.50E-04	6.70E-07
200000.	1.59E-04	1.47E-06	1.59E-04	1.50E-06	4.58E-04	1.86E-03	1.86E-03	1.92E-06
300000.	1.62E-04	1.50E-06	1.62E-04	1.53E-06	4.68E-04	1.90E-03	1.90E-03	1.96E-06
400000.	1.40E-04	1.29E-06	1.40E-04	1.33E-06	4.04E-04	1.64E-03	1.64E-03	1.69E-06
500000.	1.13E-04	1.04E-06	1.13E-04	1.07E-06	3.26E-04	1.32E-03	1.32E-03	1.36E-06
600000.	8.80E-05	8.15E-07	8.83E-05	8.34E-07	2.54E-04	1.03E-03	1.03E-03	1.07E-06
700000.	6.80E-05	6.30E-07	6.82E-05	6.45E-07	1.97E-04	7.99E-04	7.99E-04	8.24E-07
800000.	5.25E-05	4.86E-07	5.27E-05	4.98E-07	1.52E-04	6.17E-04	6.17E-04	6.36E-07
900000.	4.05E-05	3.75E-07	4.06E-05	3.84E-07	1.17E-04	4.75E-04	4.75E-04	4.90E-07
1000000.	3.13E-05	2.89E-07	3.14E-05	2.97E-07	9.04E-05	3.67E-04	3.67E-04	3.79E-07

Appendix B
Table B-2.

** AVERAGE ANNUAL NONSPECIFIC DOSE TO POPULATION, MAMIN, IN MANREMS/YEAR

NONSPECIFIC *** NUCLIDE= RA-226 K= 12

TIME	TOT BODY	GI TRACT	GONADS	LIVER	LUNGS	MARROW	BONE	THYROID
0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40.	6.48E-10	1.35E-12	6.48E-10	1.20E-13	0.0	7.71E-09	7.71E-09	0.0
50.	1.00E-09	2.08E-12	1.00E-09	1.85E-13	0.0	1.19E-08	1.19E-08	0.0
60.	1.47E-09	3.07E-12	1.47E-09	2.73E-13	0.0	1.75E-08	1.75E-08	0.0
70.	2.09E-09	4.35E-12	2.09E-09	3.87E-13	0.0	2.49E-08	2.49E-08	0.0
80.	2.89E-09	6.01E-12	2.89E-09	5.34E-13	0.0	3.43E-08	3.43E-08	0.0
90.	3.89E-09	8.09E-12	3.89E-09	7.19E-13	0.0	4.63E-08	4.63E-08	0.0
100.	5.14E-09	1.07E-11	5.14E-09	9.51E-13	0.0	6.12E-08	6.12E-08	0.0
200.	3.03E-08	6.30E-11	3.03E-08	5.60E-12	0.0	3.60E-07	3.60E-07	0.0
300.	1.32E-07	2.75E-10	1.32E-07	2.44E-11	0.0	1.57E-06	1.57E-06	0.0
400.	3.77E-07	7.85E-10	3.77E-07	6.98E-11	0.0	4.49E-06	4.49E-06	0.0
500.	8.35E-07	1.74E-09	8.35E-07	1.54E-10	0.0	9.93E-06	9.93E-06	0.0
600.	1.57E-06	3.27E-09	1.57E-06	2.91E-10	0.0	1.87E-05	1.87E-05	0.0
700.	2.66E-06	5.54E-09	2.66E-06	4.92E-10	0.0	3.17E-05	3.17E-05	0.0
800.	4.15E-06	8.63E-09	4.15E-06	7.67E-10	0.0	4.94E-05	4.94E-05	0.0
900.	6.10E-06	1.27E-08	6.10E-06	1.13E-09	0.0	7.26E-05	7.26E-05	0.0
1000.	8.58E-06	1.78E-08	8.58E-06	1.59E-09	0.0	1.02E-04	1.02E-04	0.0
2000.	5.02E-05	1.04E-07	5.02E-05	9.28E-09	0.0	5.97E-04	5.97E-04	0.0
3000.	1.82E-04	3.79E-07	1.82E-04	3.37E-08	0.0	2.17E-03	2.17E-03	0.0
4000.	4.18E-04	8.69E-07	4.18E-04	7.73E-08	0.0	4.97E-03	4.97E-03	0.0
5000.	7.63E-04	1.59E-06	7.63E-04	1.41E-07	0.0	9.08E-03	9.08E-03	0.0
6000.	1.22E-03	2.53E-06	1.22E-03	2.25E-07	0.0	1.45E-02	1.45E-02	0.0
7000.	1.78E-03	3.69E-06	1.78E-03	3.28E-07	0.0	2.11E-02	2.11E-02	0.0
8000.	2.44E-03	5.07E-06	2.44E-03	4.51E-07	0.0	2.90E-02	2.90E-02	0.0
9000.	3.20E-03	6.66E-06	3.20E-03	5.92E-07	0.0	3.81E-02	3.81E-02	0.0
10000.	4.07E-03	8.47E-06	4.07E-03	7.53E-07	0.0	4.84E-02	4.84E-02	0.0
20000.	1.51E-02	3.14E-05	1.51E-02	2.79E-06	0.0	1.80E-01	1.80E-01	0.0
30000.	3.57E-02	7.43E-05	3.57E-02	6.60E-06	0.0	4.25E-01	4.25E-01	0.0
40000.	5.89E-02	1.23E-04	5.89E-02	1.09E-05	0.0	7.01E-01	7.01E-01	0.0
50000.	8.16E-02	1.70E-04	8.16E-02	1.51E-05	0.0	9.71E-01	9.71E-01	0.0
60000.	1.03E-01	2.14E-04	1.03E-01	1.90E-05	0.0	1.22E 00	1.22E 00	0.0
70000.	1.22E-01	2.54E-04	1.22E-01	2.26E-05	0.0	1.45E 00	1.45E 00	0.0
80000.	1.39E-01	2.89E-04	1.39E-01	2.57E-05	0.0	1.65E 00	1.65E 00	0.0
90000.	1.54E-01	3.21E-04	1.54E-01	2.85E-05	0.0	1.83E 00	1.83E 00	0.0
100000.	1.67E-01	3.48E-04	1.67E-01	3.09E-05	0.0	1.99E 00	1.99E 00	0.0
200000.	5.14E-01	1.07E-03	5.14E-01	9.50E-05	0.0	6.12E 00	6.12E 00	0.0
300000.	5.27E-01	1.10E-03	5.27E-01	9.75E-05	0.0	6.27E 00	6.27E 00	0.0
400000.	4.55E-01	9.47E-04	4.55E-01	8.42E-05	0.0	5.42E 00	5.42E 00	0.0
500000.	3.67E-01	7.64E-04	3.67E-01	6.79E-05	0.0	4.37E 00	4.37E 00	0.0
600000.	2.87E-01	5.96E-04	2.87E-01	5.30E-05	0.0	3.41E 00	3.41E 00	0.0
700000.	2.22E-01	4.61E-04	2.22E-01	4.10E-05	0.0	2.64E 00	2.64E 00	0.0
800000.	1.71E-01	3.56E-04	1.71E-01	3.16E-05	0.0	2.03E 00	2.03E 00	0.0
900000.	1.32E-01	2.74E-04	1.32E-01	2.44E-05	0.0	1.57E 00	1.57E 00	0.0
1000000.	1.02E-01	2.12E-04	1.02E-01	1.88E-05	0.0	1.21E 00	1.21E 00	0.0

APPENDIX C

AMRAW-B OUTPUT FOR BASE CASE

This appendix contains output for the full run base case for terminal storage phase, Case No. 48, and is based on the total of cancers and genetic effects.

1. Annual Damage Rates, by Zone, Nonspecific and Total

   a. Table 1-1. Zonal and Total Damages for High Population Projection ($/y).

   b. Table 1-2. Zonal and Total Damages for Low Population Projection ($/y).

2. Annual Damage Rates, by Nuclide, Total All Zones, and Nonspecific

   Tables 2-9 (50 y), -14 (100 y), -18 (500 y), -23 (1000 y), -27 (5000 y), -32 (10,000 y), -36 (50,000 y), -41 (10^5 y), -45 (5×10^5 y), -50 (10^6 y), ($/y).

3. Discounted Present Values of Damage Costs by Nuclide, and Total, Integrated Over 10^6 Years

   Table 3. Discounted Present Values ($), Discount Rate = 0.00%.

4. Number of Deaths per Time Interval

   a. Table 4-1. High Population Scenario: Number of Deaths per Time Interval (#/Δy).

   b. Table 4-2. Low Population Scenario: Number of Deaths per Time Interval (#/Δy).

5. Total Undiscounted Damages per Time Interval, by Zone

   a. Table 5-1. Total Undiscounted Damages for Each Zone for Each Time Interval - High Population ($/Δy).

b. Table 5-2. Total Undiscounted Damages for Each Zone for Each Time Interval - Low Population ($/Δy).

Appendix C

Table 1-1. (Case 48)

TABLE 1 - 1 : ZONAL AND TOTAL DAMAGES FOR HIGH POP. PROJECTION ($/YR)

TIME	REPO	EDDY	REDB	MIDO	WTZX	L"A	CHAV	RZ38	TOT.ZONE	NON-SPEC	TTOTAL
0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40.	1.61E-01	2.42E 00	1.58E 00	5.06E-01	2.34E-01	1.93E 00	2.28E 00	3.97E 00	1.31E 01	6.00E 01	7.30E 01
50.	1.70E-01	3.70E 00	2.32E 00	6.62E-01	3.03E-01	2.47E 00	3.41E 00	4.82E 00	1.79E 01	5.02E 01	6.80E 01
60.	1.69E-01	4.33E 00	2.65E 00	7.25E-01	3.31E-01	2.68E 00	3.91E 00	4.76E 00	1.96E 01	4.22E 01	6.17E 01
70.	1.62E-01	4.52E 00	2.71E 00	7.34E-01	3.34E-01	2.70E 00	4.00E 00	4.37E 00	1.95E 01	3.51E 01	5.46E 01
80.	1.52E-01	4.43E 00	2.60E 00	7.15E-01	3.25E-01	2.63E 00	3.83E 00	3.91E 00	1.86E 01	2.91E 01	4.77E 01
90.	1.43E-01	4.18E 00	2.40E 00	6.86E-01	3.12E-01	2.51E 00	3.53E 00	3.47E 00	1.72E 01	2.40E 01	4.12E 01
100.	1.35E-01	3.84E 00	2.17E 00	6.59E-01	2.99E-01	2.42E 00	3.17E 00	3.10E 00	1.58E 01	1.96E 01	3.54E 01
200.	1.98E-01	4.89E 00	2.43E 00	1.04E 00	4.71E-01	3.78E 00	3.41E 00	6.11E 00	2.23E 01	1.45E 01	3.68E 01
300.	1.74E-01	1.95E 00	1.28E 00	9.46E-01	4.28E-01	3.43E 00	1.61E 00	3.57E 00	1.35E 01	2.40E 00	1.59E 01
400.	1.89E-01	1.84E 00	1.36E 00	1.04E 00	4.71E-01	3.78E 00	1.70E 00	3.81E 00	1.42E 01	1.11E 00	1.53E 01
500.	2.04E-01	2.02E 00	1.51E 00	1.14E 00	5.14E-01	4.12E 00	1.89E 00	4.07E 00	1.55E 01	9.03E-01	1.64E 01
600.	2.19E-01	2.18E 00	1.63E 00	1.22E 00	5.52E-01	4.43E 00	2.05E 00	4.29E 00	1.66E 01	8.25E-01	1.74E 01
700.	2.31E-01	2.31E 00	1.73E 00	1.29E 00	5.84E-01	4.68E 00	2.16E 00	4.46E 00	1.74E 01	7.64E-01	1.82E 01
800.	2.40E-01	2.38E 00	1.79E 00	1.34E 00	6.07E-01	4.87E 00	2.23E 00	4.59E 00	1.81E 01	7.06E-01	1.88E 01
900.	2.46E-01	2.42E 00	1.82E 00	1.38E 00	6.25E-01	5.01E 00	2.27E 00	4.66E 00	1.84E 01	6.54E-01	1.91E 01
1000.	2.51E-01	2.44E 00	1.84E 00	1.41E 00	6.38E-01	5.12E 00	2.29E 00	4.71E 00	1.87E 01	6.07E-01	1.93E 01
2000.	3.95E-01	3.67E 00	2.80E 00	2.24E 00	1.01E 00	8.09E 00	3.44E 00	8.23E 00	2.99E 01	5.86E-01	3.05E 01
3000.	4.22E-01	3.60E 00	2.80E 00	2.40E 00	1.08E 00	8.66E 00	3.37E 00	8.53E 00	3.08E 01	4.89E-01	3.13E 01
4000.	4.91E-01	4.05E 00	3.18E 00	2.78E 00	1.26E 00	1.01E 01	3.80E 00	9.68E 00	3.53E 01	5.39E-01	3.59E 01
5000.	5.54E-01	4.51E 00	3.55E 00	3.15E 00	1.42E 00	1.14E 01	4.23E 00	1.07E 01	3.95E 01	6.23E-01	4.02E 01
6000.	6.07E-01	4.86E 00	3.86E 00	3.45E 00	1.56E 00	1.25E 01	4.57E 00	1.16E 01	4.30E 01	7.65E-01	4.37E 01
7000.	6.50E-01	5.17E 00	4.10E 00	3.69E 00	1.67E 00	1.34E 01	4.85E 00	1.23E 01	4.58E 01	1.25E 00	4.70E 01
8000.	6.85E-01	5.40E 00	4.29E 00	3.89E 00	1.76E 00	1.41E 01	5.05E 00	1.28E 01	4.80E 01	3.78E 00	5.18E 01
9000.	7.13E-01	5.62E 00	4.43E 00	4.05E 00	1.83E 00	1.47E 01	5.19E 00	1.33E 01	4.98E 01	1.16E 01	6.16E 01
10000.	7.36E-01	5.84E 00	4.55E 00	4.18E 00	1.89E 00	1.52E 01	5.31E 00	1.36E 01	5.13E 01	2.44E 01	7.57E 01
20000.	1.11E 00	8.41E 00	6.62E 00	6.27E 00	2.83E 00	2.27E 01	7.67E 00	2.22E 01	7.78E 01	3.61E 01	1.14E 02
30000.	8.54E-01	6.68E 00	4.71E 00	4.84E 00	2.19E 00	1.75E 01	5.29E 00	1.69E 01	5.90E 01	1.54E 02	2.13E 02
40000.	6.54E-01	5.44E 00	3.32E 00	3.71E 00	1.67E 00	1.34E 01	3.58E 00	1.85E 01	5.03E 01	3.03E 02	3.54E 02
50000.	5.34E-01	5.02E 00	2.63E 00	3.03E 00	1.37E 00	1.10E 01	2.80E 00	2.02E 01	4.66E 01	4.13E 02	4.60E 02
60000.	4.50E-01	4.98E 00	2.29E 00	2.55E 00	1.15E 00	9.25E 00	2.47E 00	2.01E 01	4.32E 01	4.74E 02	5.18E 02
70000.	3.78E-01	5.04E 00	2.08E 00	2.15E 00	9.71E-01	7.79E 00	2.33E 00	1.91E 01	3.99E 01	5.10E 02	5.50E 02
80000.	3.18E-01	5.10E 00	1.94E 00	1.80E 00	8.14E-01	6.53E 00	2.26E 00	1.80E 01	3.67E 01	5.30E 02	5.67E 02
90000.	2.66E-01	5.14E 00	1.83E 00	1.51E 00	6.84E-01	5.48E 00	2.22E 00	1.69E 01	3.40E 01	5.41E 02	5.75E 02
100000.	2.27E-01	5.18E 00	1.76E 00	1.29E 00	5.83E-01	4.67E 00	2.21E 00	1.59E 01	3.19E 01	5.47E 02	5.78E 02
200000.	4.47E-01	6.84E 00	4.32E 00	2.54E 00	1.15E 00	9.20E 00	5.73E 00	1.50E 01	4.52E 01	2.38E 02	2.83E 02
300000.	3.80E-01	1.23E 01	4.18E 00	2.16E 00	9.78E-01	7.82E 00	5.70E 00	4.33E 01	7.68E 01	1.32E 03	1.39E 03
400000.	4.14E-01	1.05E 01	4.01E 00	2.36E 00	1.06E 00	8.53E 00	5.34E 00	3.63E 01	6.86E 01	1.04E 03	1.11E 03
500000.	4.30E-01	8.55E 00	3.69E 00	2.45E 00	1.10E 00	8.87E 00	4.77E 00	2.88E 01	5.86E 01	7.57E 02	8.16E 02
600000.	4.34E-01	6.93E 00	3.35E 00	2.46E 00	1.11E 00	8.92E 00	4.21E 00	2.31E 01	5.05E 01	5.43E 02	5.93E 02
700000.	4.29E-01	5.72E 00	3.03E 00	2.44E 00	1.10E 00	8.84E 00	3.72E 00	1.89E 01	4.42E 01	3.92E 02	4.37E 02
800000.	4.20E-01	1.04E 01	2.76E 00	2.39E 00	1.08E 00	8.63E 00	3.32E 00	1.59E 01	4.50E 01	2.87E 02	3.32E 02
900000.	4.07E-01	3.94E 02	2.53E 00	2.31E 00	1.05E 00	8.38E 00	2.97E 00	1.35E 01	4.25E 02	2.38E 02	6.64E 02
1000000.	3.92E-01	5.95E 03	2.33E 00	2.23E 00	1.01E 00	8.09E 00	2.70E 00	1.18E 01	5.98E 03	5.66E 02	6.55E 03

Appendix C

Table 1-2. (Case 48)

TABLE 1 - 2 : ZONAL AND TOTAL DAMAGES FOR LOW POP. PROJECTION ($/YR)

TIME	REPO	EDDY	REDB	MIDD	WTEX	LEA	CHAV	REGS	TOT.ZONE	NON-SPEC	TTOTAL
0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40.	1.61E-01	8.59E-01	3.97E-01	1.44E-01	6.25E-02	5.84E-01	6.10E-01	1.41E 00	4.23E 00	6.00E 01	6.42E 01
50.	1.70E-01	1.31E 00	5.84E-01	1.89E-01	8.09E-02	7.47E-01	9.14E-01	1.71E 00	5.71E 00	5.02E 01	5.59E 01
60.	1.69E-01	1.54E 00	6.68E-01	2.07E-01	8.82E-02	8.11E-01	1.05E 00	1.69E 00	6.21E 00	4.22E 01	4.84E 01
70.	1.62E-01	1.60E 00	6.81E-01	2.10E-01	8.91E-02	8.16E-01	1.07E 00	1.55E 00	6.18E 00	3.51E 01	4.13E 01
80.	1.52E-01	1.57E 00	6.54E-01	2.04E-01	8.66E-02	7.93E-01	1.03E 00	1.38E 00	5.87E 00	2.91E 01	3.50E 01
90.	1.43E-01	1.48E 00	6.04E-01	1.96E-01	8.32E-02	7.60E-01	9.45E-01	1.23E 00	5.44E 00	2.40E 01	2.94E 01
100.	1.35E-01	1.36E 00	5.46E-01	1.88E-01	7.98E-02	7.30E-01	8.50E-01	1.10E 00	4.99E 00	1.96E 01	2.46E 01
200.	1.98E-01	1.74E 00	6.11E-01	2.97E-01	1.26E-01	1.14E 00	9.13E-01	2.16E 00	7.19E 00	1.45E 01	2.17E 01
300.	1.74E-01	6.91E-01	3.22E-01	2.70E-01	1.14E-01	1.04E 00	4.31E-01	1.30E 00	4.34E 00	2.40E 00	6.74E 00
400.	1.89E-01	6.53E-01	3.43E-01	2.98E-01	1.26E-01	1.14E 00	4.55E-01	1.35E 00	4.56E 00	1.11E 00	5.66E 00
500.	2.04E-01	7.16E-01	3.80E-01	3.25E-01	1.37E-01	1.25E 00	5.06E-01	1.44E 00	4.96E 00	9.03E-01	5.86E 00
600.	2.19E-01	7.75E-01	4.11E-01	3.49E-01	1.47E-01	1.34E 00	5.49E-01	1.52E 00	5.31E 00	8.25E-01	6.13E 00
700.	2.31E-01	8.18E-01	4.34E-01	3.69E-01	1.56E-01	1.41E 00	5.80E-01	1.58E 00	5.58E 00	7.64E-01	6.35E 00
800.	2.40E-01	8.44E-01	4.50E-01	3.84E-01	1.62E-01	1.47E 00	5.99E-01	1.62E 00	5.77E 00	7.06E-01	6.48E 00
900.	2.46E-01	8.58E-01	4.58E-01	3.93E-01	1.67E-01	1.51E 00	6.09E-01	1.65E 00	5.90E 00	6.54E-01	6.55E 00
1000.	2.51E-01	8.64E-01	4.63E-01	4.04E-01	1.70E-01	1.55E 00	6.13E-01	1.67E 00	5.98E 00	6.07E-01	6.59E 00
2000.	3.95E-01	1.30E 00	7.05E-01	6.39E-01	2.70E-01	2.44E 00	9.23E-01	2.92E 00	9.60E 00	5.86E-01	1.02E 01
3000.	4.22E-01	1.28E 00	7.05E-01	6.84E-01	2.88E-01	2.61E 00	9.02E-01	3.02E 00	9.91E 00	4.89E-01	1.04E 01
4000.	4.91E-01	1.44E 00	8.01E-01	7.96E-01	3.36E-01	3.04E 00	1.02E 00	3.43E 00	1.13E 01	5.39E-01	1.19E 01
5000.	5.54E-01	1.60E 00	8.94E-01	9.00E-01	3.79E-01	3.44E 00	1.13E 00	3.80E 00	1.27E 01	6.23E-01	1.33E 01
6000.	6.07E-01	1.72E 00	9.70E-01	9.86E-01	4.15E-01	3.77E 00	1.23E 00	4.10E 00	1.38E 01	7.65E-01	1.46E 01
7000.	6.50E-01	1.83E 00	1.03E 00	1.05E 00	4.45E-01	4.04E 00	1.30E 00	4.34E 00	1.47E 01	1.25E 00	1.59E 01
8000.	6.85E-01	1.92E 00	1.08E 00	1.11E 00	4.69E-01	4.25E 00	1.35E 00	4.54E 00	1.54E 01	3.78E 00	1.92E 01
9000.	7.13E-01	1.99E 00	1.11E 00	1.16E 00	4.88E-01	4.43E 00	1.39E 00	4.69E 00	1.60E 01	1.18E 01	2.78E 01
10000.	7.36E-01	2.07E 00	1.14E 00	1.20E 00	5.04E-01	4.58E 00	1.42E 00	4.81E 00	1.65E 01	2.44E 01	4.09E 01
20000.	1.11E 00	2.98E 00	1.67E 00	1.79E 00	7.54E-01	6.85E 00	2.06E 00	7.88E 00	2.51E 01	3.61E 01	6.12E 01
30000.	8.54E-01	2.37E 00	1.19E 00	1.38E 00	5.83E-01	5.29E 00	1.42E 00	6.00E 00	1.91E 01	1.54E 02	1.73E 02
40000.	6.54E-01	1.93E 00	8.35E-01	1.06E 00	4.46E-01	4.05E 00	9.59E-01	6.54E 00	1.65E 01	3.03E 02	3.20E 02
50000.	5.34E-01	1.78E 00	6.62E-01	8.66E-01	3.65E-01	3.32E 00	7.49E-01	7.16E 00	1.54E 01	4.13E 02	4.28E 02
60000.	4.50E-01	1.77E 00	5.75E-01	7.30E-01	3.08E-01	2.79E 00	6.63E-01	7.11E 00	1.44E 01	4.74E 02	4.89E 02
70000.	3.78E-01	1.79E 00	5.24E-01	6.14E-01	2.59E-01	2.35E 00	6.25E-01	6.78E 00	1.33E 01	5.10E 02	5.23E 02
80000.	3.18E-01	1.81E 00	4.87E-01	5.15E-01	2.17E-01	1.97E 00	6.05E-01	6.37E 00	1.23E 01	5.30E 02	5.43E 02
90000.	2.66E-01	1.82E 00	4.60E-01	4.33E-01	1.83E-01	1.65E 00	5.95E-01	5.97E 00	1.14E 01	5.41E 02	5.52E 02
100000.	2.27E-01	1.84E 00	4.42E-01	3.69E-01	1.55E-01	1.41E 00	5.93E-01	5.65E 00	1.07E 01	5.47E 02	5.57E 02
200000.	4.47E-01	2.43E 00	1.09E 00	7.27E-01	3.06E-01	2.78E 00	1.54E 00	5.31E 00	1.46E 01	2.38E 02	2.53E 02
300000.	3.80E-01	4.35E 00	1.05E 00	6.18E-01	2.61E-01	2.36E 00	1.53E 00	1.53E 01	2.59E 01	1.32E 03	1.34E 03
400000.	4.14E-01	3.74E 00	1.01E 00	6.74E-01	2.84E-01	2.58E 00	1.43E 00	1.29E 01	2.30E 01	1.04E 03	1.07E 03
500000.	4.30E-01	3.03E 00	9.29E-01	6.99E-01	2.95E-01	2.68E 00	1.28E 00	1.02E 01	1.95E 01	7.57E 02	7.77E 02
600000.	4.34E-01	2.46E 00	8.42E-01	7.03E-01	2.97E-01	2.69E 00	1.13E 00	8.19E 00	1.67E 01	5.43E 02	5.60E 02
700000.	4.29E-01	2.03E 00	7.64E-01	6.98E-01	2.94E-01	2.67E 00	9.98E-01	6.71E 00	1.46E 01	3.92E 02	4.07E 02
800000.	4.20E-01	3.74E 00	6.96E-01	6.83E-01	2.88E-01	2.61E 00	8.90E-01	5.62E 00	1.49E 01	2.87E 02	3.02E 02
900000.	4.07E-01	1.40E 02	6.37E-01	6.61E-01	2.79E-01	2.53E 00	7.97E-01	4.79E 00	1.50E 02	2.38E 02	3.88E 02
1000000.	3.92E-01	2.11E 03	5.87E-01	6.38E-01	2.69E-01	2.44E 00	7.23E-01	4.17E 00	2.12E 03	5.66E 02	2.69E 03

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Table 2-9. (Case 48) Annual Damage Rates by Nuclide

TABLE 2 - 9 : TIME PERIOD= 50.

NUCLIDE	HIGH POP	LOW POP	NON-SPEC	TOT-HIGH	TOT-LOW
C-14	3.88E-07	1.22E-07	3.46E-06	3.85E-06	3.58E-06
SR-90	9.09E 00	2.84E 00	3.61E 01	4.52E 01	3.89E 01
Y-90	7.76E-02	2.43E-02	9.02E-02	1.68E-01	1.14E-01
ZR-93	1.59E-07	5.06E-08	1.38E-06	1.53E-06	1.43E-06
NB-93M	2.13E-07	6.74E-08	9.28E-06	9.49E-06	9.35E-06
TC-99	3.92E-06	1.24E-06	2.30E-04	2.34E-04	2.31E-04
I-129	6.19E-10	2.00E-10	1.17E-09	1.79E-09	1.37E-09
CS-135	7.71E-07	2.41E-07	8.55E-06	9.32E-06	8.79E-06
CS-137	6.92E-01	2.18E-01	6.64E 00	7.33E 00	6.86E 00
PB-210	6.32E-10	2.00E-10	2.04E-09	2.67E-09	2.24E-09
RA-225	3.70E-08	1.16E-08	3.76E-07	4.13E-07	3.88E-07
RA-226	1.13E-08	3.54E-09	1.95E-07	2.06E-07	1.98E-07
TH-229	9.73E-07	3.20E-07	1.80E-07	1.18E-06	5.00E-07
TH-230	9.50E-08	3.13E-08	9.85E-09	1.05E-07	4.11E-08
NP-237	6.89E-04	2.24E-04	8.05E-04	1.49E-03	1.03E-03
NP-239	3.26E-03	1.06E-03	1.86E-05	3.28E-03	1.08E-03
PU-238	6.59E-01	2.17E-01	3.43E-02	6.93E-01	2.52E-01
PU-239	3.76E-03	1.24E-03	2.05E-04	3.97E-03	1.45E-03
PU-240	5.92E-02	1.95E-02	3.23E-03	6.24E-02	2.28E-02
PU-241	4.59E-03	1.51E-03	3.38E-04	4.92E-03	1.85E-03
AM-241	8.27E-01	2.68E-01	9.58E-01	1.78E 00	1.23E 00
AM-242M	6.34E-02	2.05E-02	8.09E-02	1.44E-01	1.01E-01
AM-243	1.75E-01	5.67E-02	2.04E-01	3.79E-01	2.61E-01
CM-242	3.33E-03	1.09E-03	1.33E-03	4.67E-03	2.43E-03
CM-244	6.20E 00	2.02E 00	6.09E 00	1.23E 01	8.10E 00

Table 2-14. (Case 48) Annual Damage Rates by Nuclide

TABLE 2 - 14 : TIME PERIOD= 100.

NUCLIDE	HIGH POP	LOW POP	NON-SPEC	TOT-HIGH	TOT-LOW
C-14	1.14E-06	3.48E-07	1.11E-05	1.22E-05	1.14E-05
SR-90	7.28E 00	2.26E 00	1.27E 01	2.00E 01	1.50E 01
Y-90	6.80E-02	2.08E-02	5.99E-02	1.28E-01	8.07E-02
ZR-93	4.77E-07	1.49E-07	2.52E-06	2.99E-06	2.66E-06
NB-93M	7.58E-07	2.35E-07	2.95E-05	3.03E-05	2.98E-05
TC-99	1.16E-05	3.58E-06	7.34E-04	7.45E-04	7.37E-04
I-129	2.12E-09	6.86E-10	1.75E-09	3.87E-09	2.43E-09
CS-135	2.27E-06	6.91E-07	1.81E-05	2.04E-05	1.88E-05
CS-137	6.61E-01	2.03E-01	4.64E 00	5.30E 00	4.85E 00
PB-210	8.00E-09	1.86E-09	7.42E-09	1.34E-08	9.28E-09
RA-225	2.65E-07	8.09E-08	2.52E-06	2.78E-06	2.60E-06
RA-226	8.38E-08	2.56E-08	1.00E-06	1.09E-06	1.03E-06
TH-229	7.39E-06	2.41E-06	4.44E-07	7.84E-06	2.85E-06
TH-230	7.07E-07	2.31E-07	2.38E-08	7.30E-07	2.54E-07
NP-237	2.16E-03	6.92E-04	8.35E-04	3.00E-03	1.53E-03
NP-239	1.14E-02	3.71E-03	2.10E-05	1.14E-02	3.73E-03
PU-238	1.43E 00	4.67E-01	2.37E-02	1.45E 00	4.90E-01
PU-239	1.24E-02	4.03E-03	2.15E-04	1.26E-02	4.25E-03
PU-240	2.42E-01	7.90E-02	4.21E-03	2.46E-01	8.32E-02
PU-241	1.25E-03	4.07E-04	2.90E-05	1.27E-03	4.36E-04
AM-241	2.41E 00	7.72E-01	9.26E-01	3.34E 00	1.70E 00
AM-242M	1.55E-01	4.94E-02	6.55E-02	2.20E-01	1.15E-01
AM-243	5.36E-01	1.72E-01	2.07E-01	7.44E-01	3.79E-01
CM-242	8.28E-03	2.69E-03	1.08E-03	9.37E-03	3.77E-03
CM-244	2.96E 00	9.51E-01	9.87E-01	3.92E 00	1.91E 00

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Table 2-18. (Case 48) Annual Damage Rates by Nuclide

TABLE 2 - 18 : TIME PERIOD= 500.

NUCLIDE	HIGH POP	LOW POP	NON-SPEC	TOT-HIGH	TOT-LOW
C-14	7.60E-06	2.34E-06	7.23E-05	7.99E-05	9.47E-05
SR-90	9.49E-03	3.19E-03	6.08E-03	1.56E-02	9.27E-03
Y-90	1.55E-04	4.77E-05	1.06E-04	2.61E-04	1.54E-04
ZR-93	3.24E-06	1.02E-06	1.16E-05	1.48E-05	1.26E-05
NB-93M	5.37E-06	1.67E-06	1.83E-04	1.88E-04	1.85E-04
TC-99	8.04E-05	2.49E-05	4.84E-03	4.92E-03	4.86E-03
I-129	1.43E-08	4.61E-09	6.78E-09	2.11E-08	1.14E-08
CS-135	1.59E-05	4.88E-06	1.02E-04	1.18E-04	1.07E-04
CS-137	3.42E-03	7.48E-04	1.39E-02	1.63E-02	1.47E-02
PB-210	1.74E-06	5.41E-07	7.13E-07	2.46E-06	1.25E-06
RA-225	9.46E-06	2.91E-06	8.14E-05	9.09E-05	8.43E-05
RA-226	1.81E-05	5.57E-06	1.63E-04	1.81E-04	1.68E-04
TH-229	2.42E-04	7.87E-05	2.61E-06	2.45E-04	8.13E-05
TH-230	4.35E-05	1.41E-05	2.64E-07	4.38E-05	1.44E-05
NP-237	1.55E-02	4.96E-03	1.05E-03	1.66E-02	6.00E-03
NP-239	7.40E-02	2.41E-02	3.81E-05	7.40E-02	2.41E-02
PU-238	7.71E-01	2.51E-01	2.03E-03	7.73E-01	2.53E-01
PU-239	1.02E-01	3.30E-02	2.80E-04	1.02E-01	3.33E-02
PU-240	1.55E 00	5.05E-01	4.30E-03	1.56E 00	5.10E-01
PU-241	1.72E-03	5.58E-04	6.33E-06	1.72E-03	5.64E-04
AM-241	9.31E 00	2.97E 00	6.24E-01	9.93E 00	3.60E 00
AM-242M	2.04E-01	6.51E-02	1.50E-02	2.19E-01	8.01E-02
AM-243	3.42E 00	1.09E 00	2.30E-01	3.65E 00	1.32E 00
CM-242	1.07E-02	3.45E-03	2.51E-04	1.09E-02	3.70E-03
CM-244	9.61E-05	3.08E-05	5.46E-06	1.02E-04	3.62E-05

Table 2-23. (Case 48) Annual Damage Rates by Nuclide

TABLE 2 - 23 : TIME PERIOD= 1000.

NUCLIDE	HIGH POP	LOW POP	NON-SPEC	TOT-HIGH	TOT-LOW
C-14	1.36E-05	4.15E-06	1.35E-04	1.49E-04	1.39E-04
SR-90	7.15E-08	2.46E-08	3.35E-08	1.05E-07	5.81E-08
Y-90	1.34E-09	4.08E-10	9.64E-10	2.31E-09	1.37E-09
ZR-93	6.32E-06	1.97E-06	2.28E-05	2.91E-05	2.48E-05
NB-93M	1.03E-05	3.18E-06	3.70E-04	3.81E-04	3.74E-04
TC-99	1.53E-04	4.70E-05	9.75E-03	9.90E-03	9.79E-03
I-129	2.91E-08	9.39E-09	1.23E-08	4.14E-08	2.17E-08
CS-135	3.01E-05	9.15E-06	1.95E-04	2.25E-04	2.04E-04
CS-137	4.57E-08	1.40E-08	2.63E-07	3.09E-07	2.77E-07
PB-210	2.01E-05	6.20E-06	6.93E-06	2.71E-05	1.31E-05
RA-225	3.82E-05	1.16E-05	3.43E-04	3.81E-04	3.54E-04
RA-226	1.82E-04	5.63E-05	1.67E-03	1.85E-03	1.73E-03
TH-229	1.05E-03	3.40E-04	6.40E-06	1.06E-03	3.47E-04
TH-230	2.26E-04	7.35E-05	7.73E-07	2.27E-04	7.43E-05
NP-237	3.30E-02	1.05E-02	1.29E-03	3.43E-02	1.18E-02
NP-239	1.45E-01	4.72E-02	5.71E-05	1.45E-01	4.73E-02
PU-238	7.64E-02	2.48E-02	9.99E-05	7.65E-02	2.49E-02
PU-239	2.69E-01	8.76E-02	3.68E-04	2.70E-01	8.80E-02
PU-240	3.04E 00	9.88E-01	4.14E-03	3.04E 00	9.92E-01
PU-241	3.38E-03	1.10E-03	6.18E-06	3.38E-03	1.10E-03
AM-241	8.54E 00	2.72E 00	3.31E-01	8.88E 00	3.05E 00
AM-242M	4.15E-02	1.32E-02	1.78E-03	4.33E-02	1.50E-02
AM-243	6.54E 00	2.08E 00	2.56E-01	6.79E 00	2.34E 00
CM-242	2.21E-03	7.14E-04	2.99E-05	2.24E-03	7.44E-04
CM-244	1.01E-12	3.23E-13	3.32E-14	1.04E-12	3.56E-13

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Table 2-27. (Case 48) Annual Damage Rates by Nuclide

TABLE 2 - 27 : TIME PERIOD= 5000.

NUCLIDE	HIGH POP	LOW POP	NON-SPEC	TOT-HIGH	TOT-LOW
C-14	4.63E-05	1.43E-05	4.41E-04	4.87E-04	4.55E-04
SR-90	0.0	0.0	0.0	0.0	0.0
Y-90	0.0	0.0	0.0	0.0	0.0
ZR-93	3.27E-05	1.02E-05	1.09E-04	1.42E-04	1.20E-04
NB-93M	5.38E-05	1.67E-05	1.81E-03	1.87E-03	1.83E-03
TC-99	8.01E-04	2.48E-04	4.83E-02	4.91E-02	4.85E-02
I-129	1.48E-07	4.68E-08	4.04E-08	2.05E-07	1.07E-07
CS-135	1.61E-04	4.93E-05	9.98E-04	1.16E-03	1.04E-03
CS-137	0.0	0.0	0.0	0.0	0.0
PB-210	1.09E-03	5.87E-04	5.38E-04	2.43E-03	1.12E-03
RA-225	9.34E-04	2.87E-04	7.95E-03	8.88E-03	8.24E-03
RA-226	1.73E-02	5.32E-03	1.49E-01	1.66E-01	1.54E-01
TH-229	2.39E-02	7.78E-03	4.13E-05	2.40E-02	7.82E-03
TH-230	5.89E-03	1.91E-03	8.47E-06	5.89E-03	1.92E-03
NP-237	1.76E-01	5.61E-02	2.81E-03	1.78E-01	5.89E-02
NP-239	5.04E-01	1.64E-01	1.54E-04	5.04E-01	1.64E-01
PU-238	8.94E-08	2.90E-08	2.70E-11	8.94E-08	2.91E-08
PU-239	3.02E 00	9.81E-01	9.54E-04	3.02E 00	9.82E-01
PU-240	1.03E 01	3.34E 00	3.28E-03	1.03E 01	3.37E 00
PU-241	1.24E-02	4.04E-03	5.26E-06	1.24E-02	4.05E-03
AM-241	1.80E 02	5.76E-01	2.88E-02	1.83E 00	6.05E-01
AM-242M	6.83E-08	2.18E-08	1.20E-09	6.95E-08	2.30E-08
AM-243	2.36E 01	7.84E 00	3.79E-01	2.40E 01	7.92E 00
CM-242	3.58E-09	1.14E-09	2.09E-11	3.60E-09	1.16E-09
CM-244	0.0	0.0	0.0	0.0	0.0

Table 2-32. (Case 48) Annual Damage Rates by Nuclide

TABLE 2 - 32 : TIME PERIOD= 10000.

NUCLIDE	HIGH POP	LOW POP	NON-SPEC	TOT-HIGH	TOT-LOW
C-14	4.39E-05	1.34E-05	4.33E-04	4.77E-04	4.47E-04
SR-90	0.0	0.0	0.0	0.0	0.0
Y-90	0.0	0.0	0.0	0.0	0.0
ZR-93	5.89E-05	1.83E-05	2.04E-04	2.63E-04	2.23E-04
NB-93M	9.66E-05	2.98E-05	3.42E-03	3.51E-03	3.45E-03
TC-99	1.70E-01	6.03E-02	2.31E 01	2.33E 01	2.32E 01
I-129	3.95E-06	1.39E-06	3.77E-06	7.72E-06	5.16E-06
CS-135	2.83E-04	8.61E-05	1.80E-03	2.08E-03	1.88E-03
CS-137	0.0	0.0	0.0	0.0	0.0
PB-210	9.84E-03	3.07E-03	2.75E-03	1.26E-02	5.78E-03
RA-225	3.37E-03	1.02E-03	3.00E-02	3.34E-02	3.10E-02
RA-226	5.85E-02	2.69E-02	7.92E-01	8.81E-01	8.19E-01
TH-229	9.24E-02	3.00E-02	1.94E-04	9.26E-02	3.02E-02
TH-230	2.34E-02	7.59E-03	2.78E-05	2.34E-02	7.62E-03
NP-237	3.28E-01	1.05E-01	4.44E-03	3.33E-01	1.09E-01
NP-239	6.05E-01	1.97E-01	1.81E-04	6.05E-01	1.97E-01
PU-238	1.95E-17	6.35E-18	3.50E-21	1.95E-17	6.35E-18
PU-239	8.19E 00	2.66E 00	1.53E-03	8.19E 00	2.66E 00
PU-240	1.18E 01	3.85E 00	2.22E-03	1.18E 01	3.85E 00
PU-241	1.55E-02	5.03E-03	3.88E-06	1.55E-02	5.04E-03
AM-241	1.75E 00	5.57E-01	2.34E-02	1.77E 00	5.80E-01
AM-242M	1.45E-17	4.62E-18	2.16E-19	1.48E-17	4.84E-18
AM-243	2.81E 01	8.96E 00	3.81E-01	2.85E 01	9.34E 00
CM-242	7.75E-19	2.50E-19	3.80E-21	7.78E-19	2.54E-19
CM-244	0.0	0.0	0.0	0.0	0.0

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Table 2-36. (Case 48) Annual Damage Rates by Nuclide

TABLE 2 - 36 : TIME PERIOD= 50000.

NUCLIDE	HIGH POP	LOW POP	NON-SPEC	TOT-HIGH	TOT-LOW
C-14	1.61E-06	5.53E-07	1.50E-05	1.66E-05	1.55E-05
SR-90	0.0	0.0	0.0	0.0	0.0
Y-90	0.0	0.0	0.0	0.0	0.0
ZR-93	2.30E-04	7.21E-05	7.46E-04	9.78E-04	8.18E-04
NB-93M	3.83E-04	1.19E-04	1.25E-02	1.29E-02	1.26E-02
TC-99	1.24E 01	4.41E 00	3.96E 02	4.09E 02	4.01E 02
I-129	3.38E-04	1.20E-04	5.92E-04	9.30E-04	7.12E-04
CS-135	1.15E-03	3.56E-04	7.85E-03	8.21E-03	7.41E-03
CS-137	0.0	0.0	0.0	0.0	0.0
PB-210	2.08E-01	6.48E-02	5.60E-02	2.64E-01	1.21E-01
RA-225	5.65E-02	1.78E-02	4.70E-01	5.24E-01	4.87E-01
RA-226	1.91E 00	5.69E-01	1.59E 01	1.78E 01	1.65E 01
TH-229	1.39E 00	4.81E-01	2.50E-03	1.39E 00	4.83E-01
TH-230	3.35E-01	1.09E-01	3.38E-04	3.36E-01	1.09E-01
NP-237	1.26E 00	4.03E-01	1.40E-02	1.27E 00	4.17E-01
NP-239	3.11E-02	1.09E-02	2.00E-05	3.13E-02	1.09E-02
PU-238	0.0	0.0	0.0	0.0	0.0
PU-239	2.34E 01	7.60E 00	2.01E-03	2.34E 01	7.60E 00
PU-240	1.21E 00	3.92E-01	1.04E-04	1.21E 00	3.92E-01
PU-241	3.47E-03	1.13E-03	4.00E-07	3.47E-03	1.13E-03
AM-241	4.03E-01	1.29E-01	4.45E-03	4.07E-01	1.33E-01
AM-242M	0.0	0.0	0.0	0.0	0.0
AM-243	3.94E 00	1.26E 00	4.38E-02	3.98E 00	1.30E 00
CM-242	0.0	0.0	0.0	0.0	0.0
CM-244	0.0	0.0	0.0	0.0	0.0

Table 2-41. (Case 48) Annual Damage Rates by Nuclide

TABLE 2 - 41 : TIME PERIOD= 100000.

NUCLIDE	HIGH POP	LOW POP	NON-SPEC	TOT-HIGH	TOT-LOW
C-14	4.80E-09	1.81E-09	4.28E-08	4.73E-08	4.43E-08
SR-90	0.0	0.0	0.0	0.0	0.0
Y-90	0.0	0.0	0.0	0.0	0.0
ZR-93	2.89E-04	9.03E-05	9.59E-04	1.25E-03	1.05E-03
NB-93M	4.76E-04	1.48E-04	1.61E-02	1.65E-02	1.62E-02
TC-99	1.42E 01	5.01E 00	5.13E 02	5.27E 02	5.18E 02
I-129	5.61E-04	1.99E-04	7.70E-04	1.33E-03	9.69E-04
CS-135	1.44E-03	4.42E-04	8.92E-03	1.04E-02	9.36E-03
CS-137	0.0	0.0	0.0	0.0	0.0
PB-210	4.18E-01	1.30E-01	1.13E-01	5.31E-01	2.43E-01
RA-225	1.33E-01	4.08E-02	1.13E 00	1.27E 00	1.18E 00
RA-226	3.79E 00	1.17E 00	3.26E 01	3.64E 01	3.37E 01
TH-229	3.42E 00	1.11E 00	6.00E-03	3.42E 00	1.11E 00
TH-230	7.12E-01	2.31E-01	7.01E-04	7.13E-01	2.32E-01
NP-237	1.61E 00	5.14E-01	1.78E-02	1.63E 00	5.31E-01
NP-239	5.04E-04	1.76E-04	3.10E-07	5.05E-04	1.76E-04
PU-238	0.0	0.0	0.0	0.0	0.0
PU-239	7.59E 00	2.45E 00	5.73E-04	7.55E 00	2.45E 00
PU-240	9.58E-03	3.11E-03	7.29E-07	9.59E-03	3.12E-03
PU-241	6.56E-05	2.13E-05	6.68E-09	6.56E-05	2.13E-05
AM-241	7.51E-03	2.40E-03	8.21E-05	7.59E-03	2.48E-03
AM-242M	0.0	0.0	0.0	0.0	0.0
AM-243	6.02E-02	1.92E-02	6.42E-04	6.08E-02	1.99E-02
CM-242	0.0	0.0	0.0	0.0	0.0
CM-244	0.0	0.0	0.0	0.0	0.0

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Table 2-45. (Case 48) Annual Damage Rates by Nuclide

TABLE 2 - 45 : TIME PERIOD= 500000.

NUCLIDE	HIGH POP	LOW POP	NON-SPEC	TOT-HIGH	TOT-LOW
C-14	7.99E-12	2.83E-12	3.58E-11	4.38E-11	3.86E-11
SR-90	0.0	0.0	0.0	0.0	0.0
Y-90	0.0	0.0	0.0	0.0	0.0
ZR-93	7.07E-04	2.25E-04	2.07E-03	2.78E-03	2.30E-03
NB-93M	1.18E-03	3.74E-04	3.43E-02	3.55E-02	3.46E-02
TC-99	2.11E 01	7.46E 00	6.78E 02	6.99E 02	6.85E 02
I-129	1.92E-03	6.79E-04	3.77E-03	5.68E-03	4.45E-03
CS-135	4.11E-03	1.30E-03	2.41E-02	2.82E-02	2.54E-02
CS-137	0.0	0.0	0.0	0.0	0.0
PB-210	1.00E 00	3.17E-01	2.64E-01	1.26E 00	5.81E-01
RA-225	9.90E-01	3.12E-01	7.48E 00	8.47E 00	7.79E 00
RA-226	9.43E 00	2.98E 00	7.15E 01	8.09E 01	7.45E 01
TH-229	2.08E 01	6.76E 00	3.62E-02	2.09E 01	6.79E 00
TH-230	1.44E 00	4.66E-01	1.41E-03	1.44E 00	4.67E-01
NP-237	3.87E 00	1.24E 00	3.94E-02	3.91E 00	1.28E 00
NP-239	2.11E-07	6.87E-08	6.26E-11	2.11E-07	6.88E-08
PU-238	0.0	0.0	0.0	0.0	0.0
PU-239	5.38E-03	1.75E-03	3.33E-07	5.38E-03	1.75E-03
PU-240	2.26E-08	7.33E-09	1.40E-12	2.26E-08	7.33E-09
PU-241	1.91E-15	6.19E-16	1.58E-19	1.91E-15	6.19E-16
AM-241	2.56E-13	8.24E-14	2.60E-15	2.59E-13	8.50E-14
AM-242M	0.0	0.0	0.0	0.0	0.0
AM-243	1.06E-05	3.40E-06	1.08E-07	1.07E-05	3.51E-06
CM-242	0.0	0.0	0.0	0.0	0.0
CM-244	0.0	0.0	0.0	0.0	0.0

Table 2-50. (Case 48) Annual Damage Rates by Nuclide

TABLE 2 - 50 : TIME PERIOD= 1000000.

NUCLIDE	HIGH POP	LOW POP	NON-SPEC	TOT-HIGH	TOT-LOW
C-14	0.0	0.0	0.0	0.0	0.0
SR-90	0.0	0.0	0.0	0.0	0.0
Y-90	0.0	0.0	0.0	0.0	0.0
ZR-93	5.63E-04	1.79E-04	1.66E-03	2.22E-03	1.83E-03
NB-93M	9.51E-04	3.01E-04	2.77E-02	2.86E-02	2.80E-02
TC-99	4.18E 00	1.48E 00	1.30E 02	1.34E 02	1.32E 02
I-129	1.88E-03	6.67E-04	3.70E-03	5.58E-03	4.36E-03
CS-135	3.66E-03	1.16E-03	2.14E-02	2.50E-02	2.25E-02
CS-137	0.0	0.0	0.0	0.0	0.0
PB-210	2.78E-01	8.81E-02	7.32E-02	3.51E-01	1.61E-01
RA-225	9.68E-01	3.06E-01	7.31E 00	8.28E 00	7.62E 00
RA-226	2.62E 00	8.26E-01	1.98E 01	2.24E 01	2.07E 01
TH-229	2.03E 01	6.59E 00	3.53E-02	2.04E 01	6.62E 00
TH-230	4.00E-01	1.30E-01	3.92E-04	4.00E-01	1.30E-01
NP-237	5.95E 03	2.11E 03	4.08E 02	6.36E 03	2.52E 03
NP-239	4.52E-04	1.60E-04	3.09E-05	4.83E-04	1.91E-04
PU-238	0.0	0.0	0.0	0.0	0.0
PU-239	3.98E-05	1.29E-05	2.47E-09	3.98E-05	1.29E-05
PU-240	2.42E-07	7.87E-08	1.50E-11	2.42E-07	7.87E-08
PU-241	1.13E-30	3.69E-31	6.55E-35	1.13E-30	3.69E-31
AM-241	1.54E-28	4.91E-29	1.60E-30	1.56E-28	5.07E-29
AM-242M	0.0	0.0	0.0	0.0	0.0
AM-243	3.40E-05	1.09E-05	3.47E-07	3.44E-05	1.13E-05
CM-242	0.0	0.0	0.0	0.0	0.0
CM-244	0.0	0.0	0.0	0.0	0.0

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Table 3. (Case 48)

TABLE 3 : DISCOUNTED PRESENT VALUES ($)
DISCOUNT RATE = 0.00 %

NUCLIDE	HIGH POPULATION DISCOUNTED	HIGH POPULATION PV $/GM	LOW POPULATION DISCOUNTED	LOW POPULATION PV $/GM
PU-240	0.37E 06		0.12E 06	
CM-244	0.96E 03		0.52E 03	
SUB TOT	3.72E 05	8.51E-03	1.21E 05	2.77E-03
RA-225	0.72E 07		0.66E 07	
TH-229	0.18E 08		0.57E 07	
NP-237	0.68E 09		0.27E 09	
PU-241	0.58E 03		0.19E 03	
AM-241	0.90E 05		0.30E 05	
SUB TOT	7.06E 08	6.82E 00	2.82E 08	2.72E 00
PB-210	0.99E 06		0.45E 06	
RA-226	0.63E 08		0.58E 08	
TH-230	0.11E 07		0.37E 06	
PU-238	0.88E 03		0.29E 03	
AM-242M	0.22E 03		0.84E 02	
CM-242	0.11E 02		0.36E 01	
SUB TOT	6.52E 07	1.00E 01	5.89E 07	9.06E 00
NP-239	0.15E 05		0.51E 04	
PU-239	0.25E 07		0.80E 06	
AM-243	0.10E 07		0.34E 06	
SUB TOT	3.51E 06	4.41E-02	1.15E 06	1.44E-02
C-14	0.32E 02		0.30E 02	
SUB TOT	3.16E 01	7.83E-04	2.98E 01	7.37E-04
SR-90	0.42E 04		0.31E 04	
Y-90	0.28E 02		0.17E 02	
SUB TOT	4.21E 03	6.70E-05	3.16E 03	5.03E-05
ZR-93	0.25E 04		0.21E 04	
NB-93M	0.32E 05		0.31E 05	
SUB TOT	3.46E 04	2.60E-04	3.35E 04	2.52E-04
TC-99	0.48E 09		0.47E 09	
SUB TOT	4.82E 08	3.13E 00	4.73E 08	3.07E 00
I-129	0.46E 04		0.36E 04	
SUB TOT	4.58E 03	7.85E-02	3.58E 03	6.13E-02
CS-135	0.26E 05		0.23E 05	
SUB TOT	2.56E 04	3.76E-04	2.30E 04	3.38E-04
CS-137	0.12E 04		0.11E 04	
SUB TOT	1.17E 03	7.69E-06	1.07E 03	7.01E-06
TOTAL	1.26E 09	1.57E 00	8.15E 08	1.01E 00

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Table 4-1. (Case 48)

TABLE 4 - 1 : HIGH POPULATION SCENARIO
NUMBER OF DEATHS PER TIME INTERVAL.($260000.)

TIME	REPO	EDDY	REBD	MIDO	WTC	LEA	CHAV	REGB	TOT.ZONE	NON-SPEC	TTOTAL
0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40.	6.19E-06	9.32E-05	6.06E-05	1.94E-05	9.01E-06	7.44E-05	8.76E-05	1.53E-04	5.03E-04	2.31E-03	2.81E-03
50.	6.55E-06	1.42E-04	8.93E-05	2.55E-05	1.17E-05	9.51E-05	1.31E-04	1.85E-04	6.87E-04	1.93E-03	2.62E-03
60.	6.51E-06	1.67E-04	1.02E-04	2.79E-05	1.27E-05	1.03E-04	1.50E-04	1.83E-04	7.53E-04	1.62E-03	2.37E-03
70.	6.23E-06	1.74E-04	1.04E-04	2.82E-05	1.28E-05	1.04E-04	1.54E-04	1.69E-04	7.51E-04	1.35E-03	2.10E-03
80.	5.85E-06	1.70E-04	1.00E-04	2.75E-05	1.25E-05	1.01E-04	1.47E-04	1.50E-04	7.15E-04	1.12E-03	1.83E-03
90.	5.49E-06	1.61E-04	9.24E-05	2.64E-05	1.20E-05	9.67E-05	1.36E-04	1.33E-04	6.63E-04	9.22E-04	1.58E-03
100.	5.17E-06	1.48E-04	8.35E-05	2.54E-05	1.15E-05	9.29E-05	1.22E-04	1.19E-04	6.07E-04	7.55E-04	1.36E-03
200.	7.63E-05	1.88E-03	9.34E-04	4.00E-04	1.81E-04	1.45E-03	1.31E-03	2.35E-03	8.59E-03	5.58E-03	1.42E-02
300.	6.67E-05	7.49E-04	4.92E-04	3.64E-04	1.64E-04	1.32E-03	6.18E-04	1.41E-03	5.19E-03	9.23E-04	6.11E-03
400.	7.25E-05	7.08E-04	5.24E-04	4.01E-04	1.81E-04	1.45E-03	6.52E-04	1.47E-03	5.46E-03	4.26E-04	5.89E-03
500.	7.86E-05	7.76E-04	5.80E-04	4.37E-04	1.98E-04	1.59E-03	7.27E-04	1.57E-03	5.95E-03	3.47E-04	6.30E-03
600.	8.41E-05	8.40E-04	6.29E-04	4.70E-04	2.12E-04	1.70E-03	7.89E-04	1.65E-03	6.38E-03	3.17E-04	6.70E-03
700.	8.87E-05	8.87E-04	6.64E-04	4.97E-04	2.24E-04	1.80E-03	8.33E-04	1.72E-03	6.71E-03	2.94E-04	7.00E-03
800.	9.22E-05	9.16E-04	6.87E-04	5.17E-04	2.34E-04	1.87E-03	8.59E-04	1.76E-03	6.94E-03	2.72E-04	7.21E-03
900.	9.46E-05	9.31E-04	7.00E-04	5.32E-04	2.40E-04	1.93E-03	8.74E-04	1.79E-03	7.09E-03	2.52E-04	7.34E-03
1000.	9.65E-05	9.38E-04	7.07E-04	5.43E-04	2.45E-04	1.97E-03	8.80E-04	1.81E-03	7.19E-03	2.34E-04	7.42E-03
2000.	1.52E-03	1.41E-02	1.08E-02	8.60E-03	3.89E-03	3.11E-02	1.32E-02	3.17E-02	1.15E-01	2.25E-03	1.17E-01
3000.	1.62E-03	1.38E-02	1.08E-02	9.21E-03	4.15E-03	3.33E-02	1.30E-02	3.28E-02	1.19E-01	1.88E-03	1.21E-01
4000.	1.89E-03	1.56E-02	1.22E-02	1.07E-02	4.84E-03	3.87E-02	1.46E-02	3.72E-02	1.36E-01	2.07E-03	1.38E-01
5000.	2.13E-03	1.73E-02	1.37E-02	1.21E-02	5.46E-03	4.38E-02	1.63E-02	4.12E-02	1.52E-01	2.40E-03	1.54E-01
6000.	2.34E-03	1.87E-02	1.48E-02	1.33E-02	5.99E-03	4.80E-02	1.76E-02	4.46E-02	1.65E-01	2.94E-03	1.68E-01
7000.	2.50E-03	1.99E-02	1.58E-02	1.42E-02	6.41E-03	5.15E-02	1.86E-02	4.72E-02	1.76E-01	4.81E-03	1.81E-01
8000.	2.63E-03	2.08E-02	1.65E-02	1.50E-02	6.76E-03	5.42E-02	1.94E-02	4.93E-02	1.85E-01	1.45E-02	1.99E-01
9000.	2.74E-03	2.16E-02	1.70E-02	1.56E-02	7.04E-03	5.64E-02	2.00E-02	5.10E-02	1.91E-01	4.56E-02	2.37E-01
10000.	2.83E-03	2.25E-02	1.75E-02	1.61E-02	7.27E-03	5.83E-02	2.04E-02	5.23E-02	1.97E-01	9.38E-02	2.91E-01
20000.	4.25E-02	3.23E-01	2.55E-01	2.41E-01	1.09E-01	8.72E-01	2.95E-01	8.56E-01	2.99E 00	1.39E 00	4.38E 00
30000.	3.29E-02	2.57E-01	1.81E-01	1.86E-01	8.41E-02	6.73E-01	2.03E-01	6.51E-01	2.27E 00	5.91E 00	8.18E 00
40000.	2.52E-02	2.09E-01	1.28E-01	1.43E-01	6.43E-02	5.16E-01	1.38E-01	7.10E-01	1.93E 00	1.17E 01	1.36E 01
50000.	2.06E-02	1.93E-01	1.01E-01	1.17E-01	5.27E-02	4.22E-01	1.08E-01	7.77E-01	1.79E 00	1.59E 01	1.77E 01
60000.	1.73E-02	1.91E-01	8.79E-02	9.82E-02	4.44E-02	3.56E-01	9.51E-02	7.72E-01	1.66E 00	1.82E 01	1.99E 01
70000.	1.46E-02	1.94E-01	8.01E-02	8.27E-02	3.74E-02	3.00E-01	8.96E-02	7.37E-01	1.53E 00	1.96E 01	2.12E 01
80000.	1.22E-02	1.96E-01	7.45E-02	6.93E-02	3.13E-02	2.51E-01	8.69E-02	6.92E-01	1.41E 00	2.04E 01	2.18E 01
90000.	1.02E-02	1.98E-01	7.03E-02	5.83E-02	2.63E-02	2.11E-01	8.54E-02	6.48E-01	1.31E 00	2.08E 01	2.21E 01
100000.	8.72E-03	1.99E-01	6.76E-02	4.96E-02	2.24E-02	1.80E-01	8.51E-02	6.13E-01	1.23E 00	2.10E 01	2.22E 01
200000.	1.72E-01	2.63E 00	1.66E 00	9.79E-01	4.41E-01	3.54E 00	2.21E 00	5.77E 00	1.74E 01	9.16E 01	1.09E 02
300000.	1.46E-01	4.71E 00	1.61E 00	8.31E-01	3.76E-01	3.01E 00	2.19E 00	1.66E 01	2.95E 01	5.07E 02	5.37E 02
400000.	1.59E-01	4.06E 00	1.54E 00	9.07E-01	4.09E-01	3.28E 00	2.05E 00	1.40E 01	2.64E 01	4.01E 02	4.27E 02
500000.	1.66E-01	3.29E 00	1.42E 00	9.41E-01	4.25E-01	3.41E 00	1.84E 00	1.11E 01	2.26E 01	2.91E 02	3.14E 02
600000.	1.67E-01	2.67E 00	1.29E 00	9.47E-01	4.28E-01	3.43E 00	1.62E 00	8.89E 00	1.94E 01	2.09E 02	2.28E 02
700000.	1.65E-01	2.20E 00	1.17E 00	9.39E-01	4.24E-01	3.40E 00	1.43E 00	7.28E 00	1.70E 01	1.51E 02	1.68E 02
800000.	1.62E-01	4.06E 00	1.06E 00	9.19E-01	4.15E-01	3.32E 00	1.28E 00	6.10E 00	1.73E 01	1.10E 02	1.28E 02
900000.	1.56E-01	1.52E 02	9.74E-01	8.90E-01	4.02E-01	3.22E 00	1.14E 00	5.20E 00	1.54E 02	9.16E 01	2.55E 02
1000000.	1.51E-01	2.29E 03	8.98E-01	8.59E-01	3.88E-01	3.11E 00	1.04E 00	4.53E 00	2.30E 03	2.18E 02	2.52E 03
TOTAL	1.65E 00	2.47E 03	1.28E 01	9.38E 00	4.23E 00	3.39E 01	1.61E 01	8.63E 01	2.63E 03	2.21E 03	4.84E 03

Appendix C

Table 4-2. (Case 48)

TABLE 4 - 2 : LOW POPULATION SCENARIO
NUMBER OF DEATHS PER TIME INTERVAL.($260000.)

TIME	REPO	EDOV	REBD	MIDO	WTE	LEA	CHAV	REGB	TOT.ZONE	NON-SPEC	TTOTAL
0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40.	6.19E-06	3.30E-05	1.53E-05	5.56E-06	2.41E-06	2.25E-05	2.35E-05	5.41E-05	1.63E-04	2.31E-03	2.47E-03
50.	6.55E-06	5.05E-05	2.25E-05	7.27E-06	3.11E-06	2.87E-05	3.51E-05	6.57E-05	2.19E-04	1.93E-03	2.15E-03
60.	6.51E-06	5.91E-05	2.57E-05	7.96E-06	3.39E-06	3.12E-05	4.03E-05	6.49E-05	2.39E-04	1.62E-03	1.86E-03
70.	6.23E-06	6.17E-05	2.62E-05	8.07E-06	3.43E-06	3.14E-05	4.12E-05	5.96E-05	2.38E-04	1.35E-03	1.59E-03
80.	5.85E-06	6.05E-05	2.52E-05	7.86E-06	3.33E-06	3.05E-05	3.95E-05	5.32E-05	2.26E-04	1.12E-03	1.34E-03
90.	5.49E-06	5.70E-05	2.32E-05	7.54E-06	3.20E-06	2.92E-05	3.64E-05	4.72E-05	2.09E-04	9.22E-04	1.13E-03
100.	5.17E-06	5.23E-05	2.10E-05	7.25E-06	3.07E-06	2.81E-05	3.27E-05	4.22E-05	1.92E-04	7.55E-04	9.46E-04
200.	7.63E-05	6.67E-04	2.35E-04	1.14E-04	4.63E-05	4.39E-04	3.51E-04	8.32E-04	2.76E-03	5.58E-03	8.34E-03
300.	6.67E-05	2.66E-04	1.24E-04	1.04E-04	4.39E-05	3.99E-04	1.66E-04	5.01E-04	1.67E-03	9.23E-04	2.59E-03
400.	7.25E-05	2.51E-04	1.32E-04	1.15E-04	4.84E-05	4.39E-04	1.75E-04	5.20E-04	1.75E-03	4.26E-04	2.18E-03
500.	7.86E-05	2.75E-04	1.46E-04	1.25E-04	5.27E-05	4.79E-04	1.95E-04	5.55E-04	1.91E-03	3.47E-04	2.25E-03
600.	8.41E-05	2.98E-04	1.58E-04	1.34E-04	5.67E-05	5.15E-04	2.11E-04	5.84E-04	2.04E-03	3.17E-04	2.36E-03
700.	8.87E-05	3.15E-04	1.67E-04	1.42E-04	5.99E-05	5.44E-04	2.23E-04	6.08E-04	2.15E-03	2.94E-04	2.44E-03
800.	9.22E-05	3.25E-04	1.73E-04	1.48E-04	6.23E-05	5.66E-04	2.30E-04	6.25E-04	2.22E-03	2.72E-04	2.49E-03
900.	9.46E-05	3.30E-04	1.76E-04	1.52E-04	6.41E-05	5.82E-04	2.34E-04	6.35E-04	2.27E-03	2.52E-04	2.52E-03
1000.	9.65E-05	3.32E-04	1.78E-04	1.55E-04	6.55E-05	5.95E-04	2.36E-04	6.41E-04	2.30E-03	2.34E-04	2.53E-03
2000.	1.52E-03	5.01E-03	2.71E-03	2.46E-03	1.04E-03	9.40E-03	3.55E-03	1.12E-02	3.69E-02	2.25E-03	3.92E-02
3000.	1.62E-03	4.90E-03	2.71E-03	2.63E-03	1.11E-03	1.01E-02	3.47E-03	1.16E-02	3.81E-02	1.88E-03	4.00E-02
4000.	1.89E-03	5.53E-03	3.08E-03	3.05E-03	1.29E-03	1.17E-02	3.92E-03	1.32E-02	4.36E-02	2.07E-03	4.57E-02
5000.	2.13E-03	6.15E-03	3.44E-03	3.46E-03	1.46E-03	1.32E-02	4.36E-03	1.46E-02	4.88E-02	2.40E-03	5.12E-02
6000.	2.34E-03	6.63E-03	3.73E-03	3.79E-03	1.60E-03	1.45E-02	4.71E-03	1.58E-02	5.31E-02	2.94E-03	5.60E-02
7000.	2.50E-03	7.05E-03	3.96E-03	4.06E-03	1.71E-03	1.55E-02	5.00E-03	1.67E-02	5.65E-02	4.81E-03	6.13E-02
8000.	2.63E-03	7.37E-03	4.15E-03	4.28E-03	1.80E-03	1.64E-02	5.21E-03	1.75E-02	5.93E-02	1.45E-02	7.38E-02
9000.	2.74E-03	7.67E-03	4.29E-03	4.45E-03	1.88E-03	1.70E-02	5.35E-03	1.81E-02	6.15E-02	4.56E-02	1.07E-01
10000.	2.83E-03	7.97E-03	4.40E-03	4.60E-03	1.94E-03	1.76E-02	5.48E-03	1.85E-02	6.33E-02	9.38E-02	1.57E-01
20000.	4.25E-02	1.15E-01	6.41E-02	6.89E-02	2.90E-02	2.63E-01	7.91E-02	3.03E-01	9.65E-01	1.39E 00	2.35E 00
30000.	3.29E-02	9.12E-02	4.56E-02	5.31E-02	2.24E-02	2.03E-01	5.45E-02	2.31E-01	7.34E-01	5.91E 00	6.65E 00
40000.	2.52E-02	7.42E-02	3.21E-02	4.08E-02	1.72E-02	1.56E-01	3.69E-02	2.52E-01	6.34E-01	1.17E 01	1.23E 01
50000.	2.06E-02	6.85E-02	2.55E-02	3.33E-02	1.41E-02	1.28E-01	2.88E-02	2.75E-01	5.94E-01	1.59E 01	1.65E 01
60000.	1.73E-02	6.79E-02	2.21E-02	2.81E-02	1.18E-02	1.07E-01	2.55E-02	2.74E-01	5.54E-01	1.82E 01	1.88E 01
70000.	1.46E-02	6.87E-02	2.02E-02	2.36E-02	9.97E-03	9.05E-02	2.40E-02	2.61E-01	5.12E-01	1.96E 01	2.01E 01
80000.	1.22E-02	6.96E-02	1.87E-02	1.99E-02	8.35E-03	7.58E-02	2.33E-02	2.45E-01	4.73E-01	2.04E 01	2.09E 01
90000.	1.02E-02	7.01E-02	1.77E-02	1.66E-02	7.02E-03	6.36E-02	2.29E-02	2.30E-01	4.38E-01	2.08E 01	2.12E 01
100000.	8.72E-03	7.06E-02	1.70E-02	1.42E-02	5.98E-03	5.43E-02	2.28E-02	2.17E-01	4.11E-01	2.10E 01	2.14E 01
200000.	1.72E-01	9.33E-01	4.18E-01	2.80E-01	1.18E-01	1.07E 00	5.91E-01	2.04E 00	5.62E 00	9.16E 01	9.72E 01
300000.	1.46E-01	1.67E 00	4.05E-01	2.38E-01	1.00E-01	9.09E-01	5.87E-01	5.90E 00	9.95E 00	5.07E 02	5.17E 02
400000.	1.59E-01	1.44E 00	3.88E-01	2.59E-01	1.09E-01	9.91E-01	5.50E-01	4.95E 00	8.85E 00	4.01E 02	4.10E 02
500000.	1.66E-01	1.17E 00	3.57E-01	2.69E-01	1.13E-01	1.03E 00	4.92E-01	3.92E 00	7.51E 00	2.91E 02	2.99E 02
600000.	1.67E-01	9.46E-01	3.24E-01	2.71E-01	1.14E-01	1.04E 00	4.34E-01	3.15E 00	6.44E 00	2.09E 02	2.15E 02
700000.	1.65E-01	7.80E-01	2.94E-01	2.68E-01	1.13E-01	1.03E 00	3.84E-01	2.58E 00	5.61E 00	1.51E 02	1.57E 02
800000.	1.62E-01	1.44E 00	2.68E-01	2.63E-01	1.11E-01	1.00E 00	3.42E-01	2.16E 00	5.75E 00	1.10E 02	1.16E 02
900000.	1.56E-01	5.38E 01	2.45E-01	2.54E-01	1.07E-01	9.74E-01	3.07E-01	1.84E 00	5.77E 01	9.16E 01	1.49E 02
1000000.	1.51E-01	8.12E 02	2.26E-01	2.43E-01	1.03E-01	9.39E-01	2.78E-01	1.60E 00	8.15E 02	2.18E 02	1.03E 03
TOTAL	1.65E 00	8.75E 02	3.22E 00	2.68E 00	1.13E 00	1.03E 01	4.33E 00	3.06E 01	9.29E 02	2.21E 03	3.13E 03

Appendix C

Table 5-1. (Case 48)

TABLE 5 - 1 : TOTAL UNDISCOUNTED DAMAGES FOR EACH ZONE FOR EACH TIME INTERVAL - HIGH POPULATION

TIME	REPO	EDDY	REBD	MIDO	WTE	LZA	CHAV	RTGB	TOT.ZONE	NON-SPEC	TTOTAL
0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40.	1.61E 00	2.42E 01	1.58E 01	5.06E 00	2.34E 00	1.93E 01	2.28E 01	3.97E 01	1.31E 02	6.00E 02	7.30E 02
50.	1.70E 00	3.70E 01	2.32E 01	6.62E 00	3.03E 00	2.47E 01	3.41E 01	4.82E 01	1.79E 02	5.02E 02	6.80E 02
60.	1.69E 00	4.33E 01	2.65E 01	7.25E 00	3.31E 00	2.68E 01	3.91E 01	4.76E 01	1.96E 02	4.22E 02	6.17E 02
70.	1.62E 00	4.52E 01	2.71E 01	7.34E 00	3.34E 00	2.70E 01	4.00E 01	4.37E 01	1.95E 02	3.51E 02	5.46E 02
80.	1.52E 00	4.43E 01	2.60E 01	7.15E 00	3.25E 00	2.63E 01	3.83E 01	3.91E 01	1.86E 02	2.91E 02	4.77E 02
90.	1.43E 00	4.18E 01	2.40E 01	6.86E 00	3.12E 00	2.51E 01	3.53E 01	3.47E 01	1.72E 02	2.40E 02	4.12E 02
100.	1.35E 00	3.84E 01	2.17E 01	6.59E 00	2.99E 00	2.42E 01	3.17E 01	3.10E 01	1.58E 02	1.96E 02	3.54E 02
200.	1.98E 01	4.89E 02	2.43E 02	1.04E 02	4.71E 01	3.78E 02	3.41E 02	6.11E 02	2.23E 03	1.45E 03	3.68E 03
300.	1.74E 01	1.95E 02	1.28E 02	9.46E 01	4.28E 01	3.43E 02	1.61E 02	3.67E 02	1.35E 03	2.40E 02	1.59E 03
400.	1.89E 01	1.84E 02	1.36E 02	1.04E 02	4.71E 01	3.78E 02	1.70E 02	3.81E 02	1.42E 03	1.11E 02	1.53E 03
500.	2.04E 01	2.92E 02	1.51E 02	1.14E 02	5.14E 01	4.12E 02	1.89E 02	4.07E 02	1.55E 03	9.03E 01	1.64E 03
600.	2.19E 01	2.18E 02	1.63E 02	1.22E 02	5.52E 01	4.43E 02	2.05E 02	4.29E 02	1.66E 03	8.25E 01	1.74E 03
700.	2.31E 01	2.31E 02	1.73E 02	1.29E 02	5.84E 01	4.68E 02	2.16E 02	4.46E 02	1.74E 03	7.64E 01	1.82E 03
800.	2.40E 01	2.38E 02	1.79E 02	1.34E 02	6.07E 01	4.87E 02	2.23E 02	4.59E 02	1.81E 03	7.06E 01	1.88E 03
900.	2.48E 01	2.42E 02	1.82E 02	1.38E 02	6.25E 01	5.01E 02	2.27E 02	4.66E 02	1.84E 03	6.54E 01	1.91E 03
1000.	2.51E 01	2.44E 02	1.84E 02	1.41E 02	6.38E 01	5.12E 02	2.29E 02	4.71E 02	1.87E 03	6.07E 01	1.93E 03
2000.	3.95E 02	3.67E 03	2.80E 03	2.24E 03	1.01E 03	8.09E 03	3.44E 03	8.25E 03	2.99E 04	5.85E 02	3.05E 04
3000.	4.22E 02	3.60E 03	2.80E 03	2.40E 03	1.08E 03	8.66E 03	3.37E 03	8.53E 03	3.08E 04	4.89E 02	3.13E 04
4000.	4.91E 02	4.05E 03	3.18E 03	2.78E 03	1.26E 03	1.01E 04	3.80E 03	9.68E 03	3.53E 04	5.39E 02	3.59E 04
5000.	5.54E 02	4.51E 03	3.55E 03	3.15E 03	1.42E 03	1.14E 04	4.23E 03	1.07E 04	3.95E 04	6.23E 02	4.02E 04
6000.	6.07E 02	4.86E 03	3.86E 03	3.45E 03	1.56E 03	1.25E 04	4.57E 03	1.16E 04	4.30E 04	7.65E 02	4.37E 04
7000.	6.50E 02	5.17E 03	4.10E 03	3.69E 03	1.67E 03	1.34E 04	4.85E 03	1.23E 04	4.58E 04	1.25E 03	4.70E 04
8000.	6.85E 02	5.40E 03	4.29E 03	3.89E 03	1.76E 03	1.41E 04	5.05E 03	1.28E 04	4.80E 04	3.78E 03	5.18E 04
9000.	7.13E 02	5.62E 03	4.43E 03	4.05E 03	1.83E 03	1.47E 04	5.19E 03	1.33E 04	4.98E 04	1.18E 04	6.16E 04
10000.	7.36E 02	5.84E 03	4.55E 03	4.18E 03	1.89E 03	1.52E 04	5.31E 03	1.36E 04	5.13E 04	2.44E 04	7.57E 04
20000.	1.11E 04	8.41E 04	6.62E 04	6.27E 04	2.83E 04	2.27E 05	7.67E 04	2.22E 05	7.78E 05	3.61E 05	1.14E 06
30000.	8.54E 03	6.68E 04	4.71E 04	4.84E 04	2.19E 04	1.75E 05	5.29E 04	1.69E 05	5.90E 05	1.54E 06	2.13E 06
40000.	6.54E 03	5.44E 04	3.32E 04	3.71E 04	1.67E 04	1.34E 05	3.58E 04	1.85E 05	5.03E 05	3.03E 06	3.54E 06
50000.	5.34E 03	5.02E 04	2.63E 04	3.03E 04	1.37E 04	1.10E 05	2.80E 04	2.02E 05	4.66E 05	4.13E 06	4.60E 06
60000.	4.50E 03	4.98E 04	2.29E 04	2.55E 04	1.15E 04	9.25E 04	2.47E 04	2.01E 05	4.32E 05	4.74E 06	5.18E 06
70000.	3.78E 03	5.04E 04	2.08E 04	2.15E 04	9.71E 03	7.79E 04	2.33E 04	1.91E 05	3.99E 05	5.10E 06	5.50E 06
80000.	3.18E 03	5.10E 04	1.94E 04	1.80E 04	8.14E 03	6.53E 04	2.26E 04	1.80E 05	3.67E 05	5.30E 06	5.67E 06
90000.	2.66E 03	5.14E 04	1.83E 04	1.51E 04	6.84E 03	5.48E 04	2.22E 04	1.69E 05	3.40E 05	5.41E 06	5.75E 06
100000.	2.27E 03	5.18E 04	1.76E 04	1.29E 04	5.83E 03	4.67E 04	2.21E 04	1.59E 05	3.19E 05	5.47E 06	5.78E 06
200000.	4.47E 04	6.84E 05	4.32E 05	2.54E 05	1.15E 05	9.20E 05	5.73E 05	1.50E 06	4.52E 06	2.38E 07	2.83E 07
300000.	3.80E 04	1.23E 06	4.18E 05	2.16E 05	9.78E 04	7.82E 05	5.70E 05	4.33E 06	7.68E 06	1.32E 08	1.39E 08
400000.	4.14E 04	1.05E 06	4.01E 05	2.36E 05	1.06E 05	8.53E 05	5.34E 05	3.63E 06	6.86E 06	1.04E 08	1.11E 08
500000.	4.30E 04	8.55E 05	3.69E 05	2.45E 05	1.10E 05	8.87E 05	4.77E 05	2.88E 06	5.86E 06	7.57E 07	8.16E 07
600000.	4.34E 04	6.93E 05	3.35E 05	2.46E 05	1.11E 05	8.92E 05	4.21E 05	2.31E 06	5.05E 06	5.43E 07	5.93E 07
700000.	4.29E 04	5.72E 05	3.03E 05	2.44E 05	1.10E 05	8.84E 05	3.72E 05	1.89E 06	4.42E 06	3.92E 07	4.37E 07
800000.	4.20E 04	1.06E 06	2.76E 05	2.39E 05	1.08E 05	8.63E 05	3.32E 05	1.59E 06	4.50E 06	2.87E 07	3.32E 07
900000.	4.07E 04	3.94E 07	2.53E 05	2.31E 05	1.05E 05	8.38E 05	2.97E 05	1.35E 06	4.25E 07	2.38E 07	6.64E 07
1000000.	3.92E 04	5.95E 08	2.33E 05	2.23E 05	1.01E 05	8.09E 05	2.70E 05	1.18E 06	5.98E 08	5.66E 07	6.55E 08
TOTAL	4.29E 05	6.41E 08	3.33E 06	2.44E 06	1.10E 06	8.82E 06	4.20E 06	2.24E 07	6.84E 08	5.73E 08	1.26E 09

Appendix C

Table 5-2. (Case 48)

TABLE 5 - 2 : TOTAL UNDISCOUNTED DAMAGES FOR EACH ZONE FOR EACH TIME INTERVAL - LOW POPULATION

TIME	REPO	EDDY	REBO	MIDO	WTE	LEA	CHAV	REGA	TOT.ZONE	NON-SPEC	TTOTAL
0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40.	1.61E 00	8.59E 00	3.97E 00	1.44E 00	6.25E-01	5.84E 00	6.10E 00	1.41E 01	4.23E 01	6.00E 02	6.42E 02
50.	1.70E 00	1.31E 01	5.84E 00	1.89E 00	8.09E-01	7.47E 00	9.14E 00	1.71E 01	5.71E 01	5.02E 02	5.59E 02
60.	1.69E 00	1.54E 01	6.68E 00	2.07E 00	8.82E-01	8.11E 00	1.05E 01	1.69E 01	6.21E 01	4.22E 02	4.84E 02
70.	1.62E 00	1.60E 01	6.81E 00	2.10E 00	8.91E-01	8.16E 00	1.07E 01	1.55E 01	6.18E 01	3.51E 02	4.13E 02
80.	1.52E 00	1.57E 01	6.54E 00	2.04E 00	8.66E-01	7.93E 00	1.03E 01	1.38E 01	5.87E 01	2.91E 02	3.50E 02
90.	1.43E 00	1.48E 01	6.04E 00	1.96E 00	8.32E-01	7.60E 00	9.45E 00	1.23E 01	5.44E 01	2.40E 02	2.94E 02
100.	1.35E 00	1.36E 01	5.46E 00	1.88E 00	7.98E-01	7.30E 00	8.50E 00	1.10E 01	4.99E 01	1.96E 02	2.46E 02
200.	1.98E 01	1.74E 02	6.11E 01	2.97E 01	1.26E 01	1.14E 02	9.13E 01	2.16E 02	7.19E 02	1.45E 03	2.17E 03
300.	1.74E 01	6.91E 01	3.22E 01	2.70E 01	1.14E 01	1.04E 02	4.31E 01	1.30E 02	4.34E 02	2.40E 02	6.74E 02
400.	1.89E 01	6.53E 01	3.43E 01	2.98E 01	1.26E 01	1.14E 02	4.55E 01	1.35E 02	4.56E 02	1.11E 02	5.66E 02
500.	2.04E 01	7.16E 01	3.80E 01	3.25E 01	1.37E 01	1.25E 02	5.06E 01	1.44E 02	4.96E 02	9.03E 01	5.86E 02
600.	2.19E 01	7.75E 01	4.11E 01	3.49E 01	1.47E 01	1.34E 02	5.49E 01	1.52E 02	5.31E 02	8.25E 01	6.13E 02
700.	2.31E 01	8.18E 01	4.34E 01	3.69E 01	1.56E 01	1.41E 02	5.80E 01	1.58E 02	5.58E 02	7.64E 01	6.35E 02
800.	2.40E 01	8.44E 01	4.50E 01	3.84E 01	1.62E 01	1.47E 02	5.99E 01	1.62E 02	5.77E 02	7.06E 01	6.48E 02
900.	2.46E 01	8.58E 01	4.58E 01	3.93E 01	1.67E 01	1.51E 02	6.09E 01	1.65E 02	5.90E 02	6.54E 01	6.55E 02
1000.	2.51E 01	8.64E 01	4.63E 01	4.04E 01	1.70E 01	1.55E 02	6.13E 01	1.67E 02	5.98E 02	6.07E 01	6.59E 02
2000.	3.95E 02	1.30E 03	7.05E 02	6.39E 02	2.70E 02	2.44E 03	9.23E 02	2.92E 03	9.60E 03	5.86E 02	1.02E 04
3000.	4.22E 02	1.28E 03	7.05E 02	6.84E 02	2.88E 02	2.61E 03	9.02E 02	3.02E 03	9.91E 03	4.89E 02	1.04E 04
4000.	4.91E 02	1.44E 03	8.01E 02	7.94E 02	3.36E 02	3.04E 03	1.02E 03	3.43E 03	1.13E 04	5.39E 02	1.19E 04
5000.	5.54E 02	1.60E 03	8.94E 02	9.00E 02	3.79E 02	3.44E 03	1.13E 03	3.80E 03	1.27E 04	6.23E 02	1.33E 04
6000.	6.07E 02	1.72E 03	9.70E 02	9.86E 02	4.15E 02	3.77E 03	1.23E 03	4.10E 03	1.38E 04	7.65E 02	1.46E 04
7000.	6.50E 02	1.83E 03	1.03E 03	1.05E 03	4.45E 02	4.04E 03	1.30E 03	4.34E 03	1.47E 04	1.23E 03	1.59E 04
8000.	6.85E 02	1.92E 03	1.08E 03	1.11E 03	4.69E 02	4.25E 03	1.35E 03	4.54E 03	1.54E 04	3.78E 03	1.92E 04
9000.	7.13E 02	1.99E 03	1.11E 03	1.15E 03	4.88E 02	4.43E 03	1.39E 03	4.69E 03	1.60E 04	1.18E 04	2.78E 04
10000.	7.36E 02	2.07E 03	1.14E 03	1.20E 03	5.04E 02	4.58E 03	1.42E 03	4.81E 03	1.65E 04	2.44E 04	4.09E 04
20000.	1.11E 04	2.98E 04	1.67E 04	1.79E 04	7.54E 03	6.85E 04	2.06E 04	7.88E 04	2.51E 05	3.61E 05	6.12E 05
30000.	8.54E 03	2.37E 04	1.19E 04	1.38E 04	5.83E 03	5.29E 04	1.42E 04	6.30E 04	1.91E 05	1.54E 05	1.73E 06
40000.	6.54E 03	1.93E 04	8.35E 03	1.06E 04	4.46E 03	4.05E 04	9.59E 03	6.54E 04	1.65E 05	3.03E 06	3.20E 06
50000.	5.34E 03	1.78E 04	6.62E 03	8.66E 03	3.65E 03	3.32E 04	7.49E 03	7.16E 04	1.54E 05	4.13E 06	4.28E 06
60000.	4.50E 03	1.77E 04	5.75E 03	7.30E 03	3.08E 03	2.79E 04	6.63E 03	7.11E 04	1.44E 05	4.74E 06	4.89E 06
70000.	3.78E 03	1.79E 04	5.24E 03	6.14E 03	2.59E 03	2.35E 04	6.25E 03	6.75E 04	1.33E 05	5.10E 06	5.23E 06
80000.	3.18E 03	1.81E 04	4.87E 03	5.15E 03	2.17E 03	1.97E 04	6.05E 03	6.37E 04	1.23E 05	5.30E 06	5.43E 06
90000.	2.66E 03	1.82E 04	4.60E 03	4.33E 03	1.83E 03	1.65E 04	5.95E 03	5.97E 04	1.14E 05	5.41E 06	5.52E 06
100000.	2.27E 03	1.84E 04	4.42E 03	3.69E 03	1.55E 03	1.41E 04	5.93E 03	5.65E 04	1.07E 05	5.47E 06	5.57E 06
200000.	4.47E 04	2.43E 05	1.09E 05	7.27E 04	3.06E 04	2.78E 05	1.54E 05	5.31E 05	1.46E 06	2.38E 07	2.53E 07
300000.	3.80E 04	4.35E 05	1.05E 05	6.18E 04	2.61E 04	2.36E 05	1.53E 05	1.53E 06	2.59E 06	1.32E 08	1.34E 08
400000.	4.14E 04	3.74E 05	1.01E 05	6.74E 04	2.84E 04	2.58E 05	1.43E 05	1.29E 06	2.30E 06	1.04E 08	1.07E 08
500000.	4.30E 04	3.03E 05	9.29E 04	6.99E 04	2.95E 04	2.68E 05	1.28E 05	1.02E 06	1.95E 06	7.57E 07	7.77E 07
600000.	4.34E 04	2.46E 05	8.42E 04	7.03E 04	2.97E 04	2.69E 05	1.13E 05	8.19E 05	1.67E 06	5.43E 07	5.60E 07
700000.	4.29E 04	2.03E 05	7.64E 04	6.98E 04	2.94E 04	2.67E 05	9.98E 04	6.71E 05	1.46E 06	3.92E 07	4.07E 07
800000.	4.20E 04	3.74E 05	6.96E 04	6.83E 04	2.88E 04	2.61E 05	8.90E 04	5.62E 05	1.49E 06	2.87E 07	3.02E 07
900000.	4.07E 04	1.40E 07	6.37E 04	6.61E 04	2.79E 04	2.53E 05	7.97E 04	4.79E 05	1.50E 07	2.38E 07	3.88E 07
1000000.	3.92E 04	2.11E 08	5.87E 04	6.38E 04	2.69E 04	2.44E 05	7.23E 04	4.17E 05	2.12E 08	5.66E 07	2.69E 08
TOTAL	4.29E 05	2.27E 08	8.38E 05	6.97E 05	2.94E 05	2.67E 06	1.12E 06	7.95E 06	2.41E 08	5.73E 08	8.15E 08

APPENDIX D

AMRAW-B OUTPUT FOR LEACH INCIDENT RELEASE TO GROUND WATER COMMENCING AT 100 YEARS

This appendix contains output for the special terminal storage case, No. 50, involving the discrete incidence of leaching and release to ground water commencing at 100 y. Calculations are based on the total of cancers and genetic effects.

1. Annual Damage Rates, by Zone and Total

   a. Table 1-1. Zonal and Total Damages for High Population Projection ($/y).

   b. Table 1-2. Zonal and Total Damages for Low Population Projection, ($/y).

2. Annual Damage Rates, by Nuclide, Total All Zones, and Nonspecific

   Tables 2-27 (5000 y), -32 (10,000 y), -36 (50,000 y), -41 (10^5 y), -45 (5×10^5 y), -50 (10^6 y), ($/y).

3. Discounted Present Values of Damage Costs by Nuclide, and Total, Integrated Over 10^6 Years

   Table 3. Discounted Present Values ($), Discount Rate = 0.00%.

4. Number of Deaths per Time Interval

   a. Table 4-1. High Population Scenario: Number of Deaths per Time Interval (#/Δy).

   b. Table 4-2. Low Population Scenario: Number of Deaths per Time Interval (#/Δy).

5. Total Undiscounted Damages per Time Interval, by Zone

   a. Table 5-1. Total Undiscounted Damages for Each Zone for Each Time Interval - High Population ($/Δy).

b. Table 5-2. Total Undiscounted Damages for Each Zone for Each Time Interval - Low Population ($/Δy).

Appendix D

Table 1-1. (Case 50)

TABLE 1 - 1 : ZONAL AND TOTAL DAMAGES FOR HIGH POP. PROJECTION ($/YR)

TIME	REPO	EDDY	REDB	MIDO	WTEX	LEA	CHAV	REGB	TOT.ZONE	NON-SPEC	TTOTAL
0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
300.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
400.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
600.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
700.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
800.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
900.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1000.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2000.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.50E-17	3.42E-15	3.45E-15
3000.	0.0	2.50E-17	0.0	0.0	0.0	0.0	0.0	0.0	6.69E-07	9.17E-05	9.24E-05
4000.	0.0	6.69E-07	0.0	0.0	0.0	0.0	0.0	0.0	7.53E-02	1.03E 01	1.04E 01
5000.	0.0	7.53E-02	0.0	0.0	0.0	0.0	0.0	4.04E-32	1.90E 01	2.62E 03	2.63E 03
6000.	0.0	1.90E 01	0.0	0.0	0.0	0.0	0.0	1.87E-20	1.97E 02	2.70E 04	2.72E 04
7000.	0.0	1.97E 02	0.0	0.0	0.0	0.0	0.0	1.77E-12	5.80E 02	7.97E 04	8.02E 04
8000.	0.0	5.80E 02	0.0	0.0	0.0	0.0	0.0	5.81E-07	1.12E 03	1.54E 05	1.55E 05
9000.	0.0	1.12E 03	0.0	0.0	0.0	0.0	0.0	3.69E-03	1.76E 03	2.42E 05	2.44E 05
10000.	0.0	1.76E 03	0.0	0.0	0.0	0.0	0.0	2.79E 03	4.76E 03	3.01E 05	3.06E 05
20000.	0.0	1.97E 03	0.0	0.0	0.0	0.0	0.0	4.17E 03	6.30E 03	3.38E 05	3.45E 05
30000.	0.0	2.13E 03	0.0	0.0	0.0	0.0	0.0	6.65E 03	8.87E 03	3.79E 05	3.87E 05
40000.	0.0	2.22E 03	0.0	0.0	0.0	0.0	0.0	8.25E 03	1.05E 04	4.05E 05	4.15E 05
50000.	0.0	2.27E 03	0.0	0.0	0.0	0.0	0.0	8.73E 03	1.10E 04	4.14E 05	4.25E 05
60000.	0.0	2.31E 03	0.0	0.0	0.0	0.0	0.0	8.73E 03	1.10E 04	4.14E 05	4.25E 05
70000.	0.0	2.31E 03	0.0	0.0	0.0	0.0	0.0	8.55E 03	1.08E 04	4.11E 05	4.21E 05
80000.	0.0	2.29E 03	0.0	0.0	0.0	0.0	0.0	8.31E 03	1.06E 04	4.03E 05	4.14E 05
90000.	0.0	2.26E 03	0.0	0.0	0.0	0.0	0.0	8.10E 03	1.03E 04	3.96E 05	4.07E 05
100000.	0.0	2.23E 03	0.0	0.0	0.0	0.0	0.0	1.99E 03	2.48E 03	1.07E 05	1.05E 05
200000.	0.0	5.88E 02	0.0	0.0	0.0	0.0	0.0	2.34E 03	2.82E 03	9.25E 04	9.53E 04
300000.	0.0	4.80E 02	0.0	0.0	0.0	0.0	0.0	1.77E 03	2.12E 03	6.82E 04	7.04E 04
400000.	0.0	3.58E 02	0.0	0.0	0.0	0.0	0.0	1.26E 03	1.51E 03	4.84E 04	4.99E 04
500000.	0.0	2.48E 02	0.0	0.0	0.0	0.0	0.0	8.96E 02	1.07E 03	3.42E 04	3.53E 04
600000.	0.0	1.76E 02	0.0	0.0	0.0	0.0	0.0	6.42E 02	7.81E 02	2.44E 04	2.51E 04
700000.	0.0	1.39E 02	0.0	0.0	0.0	0.0	0.0	4.65E 02	7.61E 03	1.80E 04	2.56E 04
800000.	0.0	7.15E 03	0.0	0.0	0.0	0.0	0.0	3.40E 02	3.89E 05	3.94E 04	4.28E 05
900000.	0.0	3.89E 05	0.0	0.0	0.0	0.0	0.0	2.51E 02	4.82E 06	3.39E 05	5.16E 06
1000000.	0.0	4.82E 06	0.0	0.0	0.0	0.0	0.0				

Appendix D

Table 1-2. (Case 50)

TABLE 1 - 2 : ZONAL AND TOTAL DAMAGES FOR LOW POP. PROJECTION ($/YR)

TIME	REPO	EDDY	REDB	WIDO	WTEX	LEA	CHAV	REGB	TOT.ZONE	NON-SPEC	TTOTAL
0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
300.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
400.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
600.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
700.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
800.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
900.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1000.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2000.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3000.	0.0	8.86E-18	0.0	0.0	0.0	0.0	0.0	0.0	8.86E-18	3.42E-15	3.43E-15
4000.	0.0	2.37E-07	0.0	0.0	0.0	0.0	0.0	0.0	2.37E-07	9.17E-05	9.20E-05
5000.	0.0	2.67E-02	0.0	0.0	0.0	0.0	0.0	0.0	2.67E-02	1.03E 01	1.03E 01
6000.	0.0	6.75E 00	0.0	0.0	0.0	0.0	0.0	1.43E-32	6.75E 00	2.62E 03	2.62E 03
7000.	0.0	6.97E 01	0.0	0.0	0.0	0.0	0.0	6.64E-21	6.97E 01	2.70E 04	2.71E 04
8000.	0.0	2.06E 02	0.0	0.0	0.0	0.0	0.0	6.29E-13	2.06E 02	7.97E 04	7.99E 04
9000.	0.0	3.96E 02	0.0	0.0	0.0	0.0	0.0	2.06E-07	3.96E 02	1.54E 05	1.54E 05
10000.	0.0	6.23E 02	0.0	0.0	0.0	0.0	0.0	1.31E-03	6.23E 02	2.42E 05	2.42E 05
20000.	0.0	6.98E 02	0.0	0.0	0.0	0.0	0.0	9.88E 02	1.69E 03	3.01E 05	3.03E 05
30000.	0.0	7.55E 02	0.0	0.0	0.0	0.0	0.0	1.48E 03	2.23E 03	3.38E 05	3.41E 05
40000.	0.0	7.89E 02	0.0	0.0	0.0	0.0	0.0	2.35E 03	3.14E 03	3.79E 05	3.83E 05
50000.	0.0	8.06E 02	0.0	0.0	0.0	0.0	0.0	2.92E 03	3.73E 03	4.05E 05	4.09E 05
60000.	0.0	8.18E 02	0.0	0.0	0.0	0.0	0.0	3.99E 03	3.91E 03	4.14E 05	4.18E 05
70000.	0.0	8.18E 02	0.0	0.0	0.0	0.0	0.0	3.99E 03	3.91E 03	4.14E 05	4.18E 05
80000.	0.0	8.12E 02	0.0	0.0	0.0	0.0	0.0	3.03E 03	3.84E 03	4.11E 05	4.14E 05
90000.	0.0	8.05E 02	0.0	0.0	0.0	0.0	0.0	2.94E 03	3.74E 03	4.03E 05	4.07E 05
100000.	0.0	7.89E 02	0.0	0.0	0.0	0.0	0.0	2.87E 03	3.66E 03	3.96E 05	4.00E 05
200000.	0.0	2.09E 02	0.0	0.0	0.0	0.0	0.0	6.71E 02	8.80E 02	1.02E 05	1.03E 05
300000.	0.0	1.70E 02	0.0	0.0	0.0	0.0	0.0	8.29E 02	1.00E 03	9.25E 04	9.35E 04
400000.	0.0	1.24E 02	0.0	0.0	0.0	0.0	0.0	6.28E 02	7.52E 02	6.82E 04	6.90E 04
500000.	0.0	8.80E 01	0.0	0.0	0.0	0.0	0.0	4.46E 02	5.34E 02	4.84E 04	4.89E 04
600000.	0.0	6.23E 01	0.0	0.0	0.0	0.0	0.0	3.18E 02	3.80E 02	3.42E 04	3.46E 04
700000.	0.0	4.94E 01	0.0	0.0	0.0	0.0	0.0	2.27E 02	2.77E 02	2.44E 04	2.46E 04
800000.	0.0	2.54E 03	0.0	0.0	0.0	0.0	0.0	1.65E 02	2.70E 03	1.80E 04	2.07E 04
900000.	0.0	1.38E 05	0.0	0.0	0.0	0.0	0.0	1.20E 02	1.38E 05	3.94E 04	1.77E 05
1000000.	0.0	1.71E 06	0.0	0.0	0.0	0.0	0.0	8.91E 01	1.71E 06	3.39E 05	2.05E 06

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Table 2-27. (Case 50) Annual Damage Rates by Nuclide

TABLE 2 - 27 : TIME PERIOD= 5000.

NUCLIDE	HIGH POP	LOW POP	NON-SPEC	TOT-HIGH	TOT-LOW
C-14	0.0	0.0	0.0	0.0	0.0
SR-90	0.0	0.0	0.0	0.0	0.0
Y-90	0.0	0.0	0.0	0.0	0.0
ZR-93	0.0	0.0	0.0	0.0	0.0
NB-93M	0.0	0.0	0.0	0.0	0.0
TC-99	7.53E-02	2.67E-02	1.03E 01	1.04E 01	1.03E 01
I-129	1.65E-06	5.85E-07	1.64E-06	3.29E-06	2.23E-06
CS-135	0.0	0.0	0.0	0.0	0.0
CS-137	0.0	0.0	0.0	0.0	0.0
PB-210	0.0	0.0	0.0	0.0	0.0
RA-225	0.0	0.0	0.0	0.0	0.0
RA-226	0.0	0.0	0.0	0.0	0.0
TH-229	0.0	0.0	0.0	0.0	0.0
TH-230	0.0	0.0	0.0	0.0	0.0
NP-237	0.0	0.0	0.0	0.0	0.0
NP-239	0.0	0.0	0.0	0.0	0.0
PU-238	0.0	0.0	0.0	0.0	0.0
PU-239	0.0	0.0	0.0	0.0	0.0
PU-240	0.0	0.0	0.0	0.0	0.0
PU-241	0.0	0.0	0.0	0.0	0.0
AM-241	0.0	0.0	0.0	0.0	0.0
AM-242M	0.0	0.0	0.0	0.0	0.0
AM-243	0.0	0.0	0.0	0.0	0.0
CM-242	0.0	0.0	0.0	0.0	0.0
CM-244	0.0	0.0	0.0	0.0	0.0

Table 2-32. (Case 50) Annual Damage Rates by Nuclide

TABLE 2 - 32 : TIME PERIOD= 10000.

NUCLIDE	HIGH POP	LOW POP	NON-SPEC	TOT-HIGH	TOT-LOW
C-14	0.0	0.0	0.0	0.0	0.0
SR-90	0.0	0.0	0.0	0.0	0.0
Y-90	0.0	0.0	0.0	0.0	0.0
ZR-93	0.0	0.0	0.0	0.0	0.0
NB-93M	0.0	0.0	0.0	0.0	0.0
TC-99	1.76E 03	6.23E 02	2.42E 05	2.44E 05	2.42E 05
I-129	3.85E-02	1.36E-02	3.83E-02	7.68E-02	5.19E-02
CS-135	0.0	0.0	0.0	0.0	0.0
CS-137	0.0	0.0	0.0	0.0	0.0
PB-210	0.0	0.0	0.0	0.0	0.0
RA-225	0.0	0.0	0.0	0.0	0.0
RA-226	0.0	0.0	0.0	0.0	0.0
TH-229	0.0	0.0	0.0	0.0	0.0
TH-230	0.0	0.0	0.0	0.0	0.0
NP-237	0.0	0.0	0.0	0.0	0.0
NP-239	0.0	0.0	0.0	0.0	0.0
PU-238	0.0	0.0	0.0	0.0	0.0
PU-239	0.0	0.0	0.0	0.0	0.0
PU-240	0.0	0.0	0.0	0.0	0.0
PU-241	0.0	0.0	0.0	0.0	0.0
AM-241	0.0	0.0	0.0	0.0	0.0
AM-242M	0.0	0.0	0.0	0.0	0.0
AM-243	0.0	0.0	0.0	0.0	0.0
CM-242	0.0	0.0	0.0	0.0	0.0
CM-244	0.0	0.0	0.0	0.0	0.0

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Table 2-36. (Case 50) Annual Damage Rates by Nuclide

TABLE 2 - 36 : TIME PERIOD= 50000.

NUCLIDE	HIGH POP	LOW POP	NON-SPEC	TOT-HIGH	TOT-LOW
C-14	9.74E-33	3.46E-33	1.04E-31	1.13E-31	1.07E-31
SR-90	0.0	0.0	0.0	0.0	0.0
Y-90	0.0	0.0	0.0	0.0	0.0
ZR-93	0.0	0.0	0.0	0.0	0.0
NB-93M	0.0	0.0	0.0	0.0	0.0
TC-99	1.05E 04	3.73E 03	4.05E 05	4.15E 05	4.09E 05
I-129	3.03E-01	1.07E-01	4.87E-01	7.90E-01	5.95E-01
CS-135	0.0	0.0	0.0	0.0	0.0
CS-137	0.0	0.0	0.0	0.0	0.0
PB-210	0.0	0.0	0.0	0.0	0.0
RA-225	0.0	0.0	0.0	0.0	0.0
RA-226	0.0	0.0	0.0	0.0	0.0
TH-229	0.0	0.0	0.0	0.0	0.0
TH-230	0.0	0.0	0.0	0.0	0.0
NP-237	0.0	0.0	0.0	0.0	0.0
NP-239	0.0	0.0	0.0	0.0	0.0
PU-238	0.0	0.0	0.0	0.0	0.0
PU-239	0.0	0.0	0.0	0.0	0.0
PU-240	0.0	0.0	0.0	0.0	0.0
PU-241	0.0	0.0	0.0	0.0	0.0
AM-241	0.0	0.0	0.0	0.0	0.0
AM-242M	0.0	0.0	0.0	0.0	0.0
AM-243	0.0	0.0	0.0	0.0	0.0
CM-242	0.0	0.0	0.0	0.0	0.0
CM-244	0.0	0.0	0.0	0.0	0.0

Table 2-41. (Case 50) Annual Damage Rates by Nuclide

TABLE 2 - 41 : TIME PERIOD= 100000.

NUCLIDE	HIGH POP	LOW POP	NON-SPEC	TOT-HIGH	TOT-LOW
C-14	1.24E-07	4.41E-08	1.32E-06	1.45E-06	1.37E-06
SR-90	0.0	0.0	0.0	0.0	0.0
Y-90	0.0	0.0	0.0	0.0	0.0
ZR-93	0.0	0.0	0.0	0.0	0.0
NB-93M	0.0	0.0	0.0	0.0	0.0
TC-99	1.03E 04	3.66E 03	3.96E 05	4.07E 05	4.02E 05
I-129	4.15E-01	1.47E-01	9.56E-01	9.71E-01	7.03E-01
CS-135	0.0	0.0	0.0	0.0	0.0
CS-137	0.0	0.0	0.0	0.0	0.0
PB-210	0.0	0.0	0.0	0.0	0.0
RA-225	0.0	0.0	0.0	0.0	0.0
RA-226	0.0	0.0	0.0	0.0	0.0
TH-229	0.0	0.0	0.0	0.0	0.0
TH-230	0.0	0.0	0.0	0.0	0.0
NP-237	0.0	0.0	0.0	0.0	0.0
NP-239	0.0	0.0	0.0	0.0	0.0
PU-238	0.0	0.0	0.0	0.0	0.0
PU-239	0.0	0.0	0.0	0.0	0.0
PU-240	0.0	0.0	0.0	0.0	0.0
PU-241	0.0	0.0	0.0	0.0	0.0
AM-241	0.0	0.0	0.0	0.0	0.0
AM-242M	0.0	0.0	0.0	0.0	0.0
AM-243	0.0	0.0	0.0	0.0	0.0
CM-242	0.0	0.0	0.0	0.0	0.0
CM-244	0.0	0.0	0.0	0.0	0.0

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Table 2-45. (Case 50) Annual Damage Rates by Nuclide

TABLE 2 - 45 : TIME PERIOD= 500000.

NUCLIDE	HIGH POP	LOW POP	NON-SPEC	TOT-HIGH	TOT-LOW
C-14	0.17E-09	2.18E-09	2.75E-08	3.37E-08	2.97E-08
SR-90	0.0	0.0	0.0	0.0	0.0
Y-90	0.0	0.0	0.0	0.0	0.0
ZR-93	0.0	0.0	0.0	0.0	0.0
NB-93M	0.0	0.0	0.0	0.0	0.0
TC-99	1.51E 03	5.34E 02	4.84E 04	4.99E 04	4.89E 04
I-129	1.37E-01	4.85E-02	2.69E-01	4.06E-01	3.18E-01
CS-135	0.0	0.0	0.0	0.0	0.0
CS-137	0.0	0.0	0.0	0.0	0.0
PB-210	0.0	0.0	0.0	0.0	0.0
RA-225	0.0	0.0	0.0	0.0	0.0
RA-226	0.0	0.0	0.0	0.0	0.0
TH-229	0.0	0.0	0.0	0.0	0.0
TH-230	0.0	0.0	0.0	0.0	0.0
NP-237	4.98E-10	1.77E-10	3.41E-11	5.32E-10	2.11E-10
NP-239	6.71E-19	2.38E-19	4.61E-20	7.17E-19	2.84E-19
PU-238	0.0	0.0	0.0	0.0	0.0
PU-239	0.0	0.0	0.0	0.0	0.0
PU-240	0.0	0.0	0.0	0.0	0.0
PU-241	0.0	0.0	0.0	0.0	0.0
AM-241	0.0	0.0	0.0	0.0	0.0
AM-242M	0.0	0.0	0.0	0.0	0.0
AM-243	0.0	0.0	0.0	0.0	0.0
CM-242	0.0	0.0	0.0	0.0	0.0
CM-244	0.0	0.0	0.0	0.0	0.0

Table 2-50. (Case 50) Annual Damages Rates by Nuclide

TABLE 2 - 50 : TIME PERIOD= 1000000.

NUCLIDE	HIGH POP	LOW POP	NON-SPEC	TOT-HIGH	TOT-LOW
C-14	0.0	0.0	0.0	0.0	0.0
SR-90	0.0	0.0	0.0	0.0	0.0
Y-90	0.0	0.0	0.0	0.0	0.0
ZR-93	0.0	0.0	0.0	0.0	0.0
NB-93M	0.0	0.0	0.0	0.0	0.0
TC-99	2.98E 02	1.06E 02	9.33E 03	9.63E 03	9.43E 03
I-129	1.34E-01	4.75E-02	2.64E-01	3.98E-01	3.11E-01
CS-135	0.0	0.0	0.0	0.0	0.0
CS-137	0.0	0.0	0.0	0.0	0.0
PB-210	0.0	0.0	0.0	0.0	0.0
RA-225	0.0	0.0	0.0	0.0	0.0
RA-226	0.0	0.0	0.0	0.0	0.0
TH-229	0.0	0.0	0.0	0.0	0.0
TH-230	0.0	0.0	0.0	0.0	0.0
NP-237	4.82E 06	1.71E 06	3.30E 05	5.15E 06	2.04E 06
NP-239	6.32E-02	2.05E-02	5.71E-03	6.89E-02	3.52E-02
PU-238	0.0	0.0	0.0	0.0	0.0
PU-239	0.0	0.0	0.0	0.0	0.0
PU-240	0.0	0.0	0.0	0.0	0.0
PU-241	0.0	0.0	0.0	0.0	0.0
AM-241	0.0	0.0	0.0	0.0	0.0
AM-242M	0.0	0.0	0.0	0.0	0.0
AM-243	0.0	0.0	0.0	0.0	0.0
CM-242	0.0	0.0	0.0	0.0	0.0
CM-244	0.0	0.0	0.0	0.0	0.0

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Table 3. (Case 50)

TABLE 3 : DISCOUNTED PRESENT VALUES ($)
DISCOUNT RATE = 0.00 %

NUCLIDE	HIGH POPULATION DISCOUNTED	HIGH POPULATION PV $/GW	LOW POPULATION DISCOUNTED	LOW POPULATION PV $/GW
PU-240	0.0		0.0	
CM-244	0.0		0.0	
SUB TOT	0.0	0.0	0.0	0.0
RA-225	0.0		0.0	
TH-229	0.0		0.0	
NP-237	0.58E 12		0.22E 12	
PU-241	0.0		0.0	
AM-241	0.0		0.0	
SUB TOT	5.57E 11	5.38E 03	2.21E 11	2.13E 03
PB-210	0.0		0.0	
RA-226	0.0		0.0	
TH-230	0.0		0.0	
PU-238	0.0		0.0	
AM-242M	0.0		0.0	
CM-242	0.0		0.0	
SUB TOT	0.0	0.0	0.0	0.0
NP-239	0.91E 04		0.36E 04	
PU-239	0.0		0.0	
AM-243	0.0		0.0	
SUB TOT	9.15E 03	1.15E-04	3.62E 03	4.55E-05
C-14	0.19E 05		0.19E 05	
SUB TOT	1.88E 04	4.64E-01	1.77E 04	4.38E-01
SR-90	0.0		0.0	
Y-90	0.0		0.0	
SUB TOT	0.0	0.0	0.0	0.0
ZR-93	0.0		0.0	
NB-93M	0.0		0.0	
SUB TOT	0.0	0.0	0.0	0.0
TC-99	0.78E 11		0.77E 11	
SUB TOT	7.81E 10	5.07E 02	7.68E 10	4.99E 02
I-129	0.42E 06		0.32E 06	
SUB TOT	4.18E 05	7.16E 00	3.22E 05	5.51E 00
CS-135	0.0		0.0	
SUB TOT	0.0	0.0	0.0	0.0
CS-137	0.0		0.0	
SUB TOT	0.0	0.0	0.0	0.0
TOTAL	6.35E 11	7.01E 02	2.97E 11	3.70E 02

Appendix D

Table 4-1. (Case 50)

TABLE 4 - 1 : HIGH POPULATION SCENARIO
NUMBER OF DEATHS PER TIME INTERVAL.($260000.)

TIME	REPO	EDDY	REBO	MIDJ	WTE	LEA	CHAV	REGB	TOT.ZONE	NON-SPEC	TTOTAL
0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
300.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
400.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
600.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
700.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
800.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
900.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1000.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2000.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3000.	0.0	9.61E-20	0.0	0.0	0.0	0.0	0.0	0.0	9.61E-20	1.32E-17	1.33E-17
4000.	0.0	2.57E-09	0.0	0.0	0.0	0.0	0.0	0.0	2.57E-09	3.53E-07	3.55E-07
5000.	0.0	2.90E-04	0.0	0.0	0.0	0.0	0.0	0.0	2.90E-04	3.97E-02	3.99E-02
6000.	0.0	7.32E-02	0.0	0.0	0.0	0.0	0.0	1.55E-34	7.32E-02	1.01E 01	1.01E 01
7000.	0.0	7.56E-01	0.0	0.0	0.0	0.0	0.0	7.21E-23	7.56E-01	1.04E 02	1.05E 02
8000.	0.0	2.23E 00	0.0	0.0	0.0	0.0	0.0	6.82E-15	2.23E 00	3.06E 02	3.09E 02
9000.	0.0	4.30E 00	0.0	0.0	0.0	0.0	0.0	2.23E-09	4.30E 00	5.91E 02	5.95E 02
10000.	0.0	6.76E 00	0.0	0.0	0.0	0.0	0.0	1.42E-05	6.76E 00	9.30E 02	9.37E 02
20000.	0.0	7.57E 01	0.0	0.0	0.0	0.0	0.0	1.07E 02	1.83E 02	1.16E 04	1.18E 04
30000.	0.0	8.18E 01	0.0	0.0	0.0	0.0	0.0	1.60E 02	2.42E 02	1.30E 04	1.33E 04
40000.	0.0	8.56E 01	0.0	0.0	0.0	0.0	0.0	2.56E 02	3.41E 02	1.46E 04	1.49E 04
50000.	0.0	8.74E 01	0.0	0.0	0.0	0.0	0.0	3.17E 02	4.05E 02	1.56E 04	1.60E 04
60000.	0.0	8.87E 01	0.0	0.0	0.0	0.0	0.0	3.36E 02	4.25E 02	1.59E 04	1.64E 04
70000.	0.0	8.87E 01	0.0	0.0	0.0	0.0	0.0	3.36E 02	4.24E 02	1.59E 04	1.64E 04
80000.	0.0	8.81E 01	0.0	0.0	0.0	0.0	0.0	3.29E 02	4.17E 02	1.58E 04	1.62E 04
90000.	0.0	8.68E 01	0.0	0.0	0.0	0.0	0.0	3.20E 02	4.07E 02	1.55E 04	1.59E 04
100000.	0.0	8.56E 01	0.0	0.0	0.0	0.0	0.0	3.12E 02	3.97E 02	1.52E 04	1.56E 04
200000.	0.0	2.26E 02	0.0	0.0	0.0	0.0	0.0	7.29E 02	9.55E 02	3.93E 04	4.02E 04
300000.	0.0	1.85E 02	0.0	0.0	0.0	0.0	0.0	9.00E 02	1.09E 03	3.56E 04	3.67E 04
400000.	0.0	1.35E 02	0.0	0.0	0.0	0.0	0.0	6.82E 02	8.16E 02	2.62E 04	2.71E 04
500000.	0.0	9.55E 01	0.0	0.0	0.0	0.0	0.0	4.84E 02	5.79E 02	1.86E 04	1.92E 04
600000.	0.0	6.76E 01	0.0	0.0	0.0	0.0	0.0	3.45E 02	4.12E 02	1.32E 04	1.36E 04
700000.	0.0	5.35E 01	0.0	0.0	0.0	0.0	0.0	2.47E 02	3.01E 02	9.37E 03	9.67E 03
800000.	0.0	2.75E 03	0.0	0.0	0.0	0.0	0.0	1.79E 02	2.93E 03	6.93E 03	9.86E 03
900000.	0.0	1.50E 05	0.0	0.0	0.0	0.0	0.0	1.31E 02	1.50E 05	1.51E 04	1.65E 05
1000000.	0.0	1.85E 06	0.0	0.0	0.0	0.0	0.0	9.67E 01	1.85E 06	1.30E 05	1.98E 06
TOTAL	0.0	2.01E 06	0.0	0.0	0.0	0.0	0.0	6.27E 03	2.01E 06	4.30E 05	2.44E 06

Appendix D

Table 4-2. (Case 50)

TABLE 4 - 2 : LOW POPULATION SCENARIO
NUMBER OF DEATHS PER TIME INTERVAL.(\$200000.)

TIME	REPO	EDDY	REBD	MIDD	WTE	LEA	CHAV	REGS	TOT.ZONE	NON-SPEC	TTOTAL
0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
300.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
400.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
600.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
700.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
800.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
900.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1000.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2000.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.41E-20	1.32E-17	1.32E-17
3000.	0.0	3.41E-20	0.0	0.0	0.0	0.0	0.0	0.0	9.13E-10	3.53E-07	3.54E-07
4000.	0.0	9.13E-10	0.0	0.0	0.0	0.0	0.0	0.0	1.03E-04	3.97E-02	3.98E-02
5000.	0.0	1.03E-04	0.0	0.0	0.0	0.0	0.0	5.50E-35	2.60E-02	1.01E 01	1.01E 01
6000.	0.0	2.60E-02	0.0	0.0	0.0	0.0	0.0	2.55E-23	2.68E-01	1.04E 02	1.04E 02
7000.	0.0	2.68E-01	0.0	0.0	0.0	0.0	0.0	2.41E-15	7.92E-01	3.06E 02	3.07E 02
8000.	0.0	7.92E-01	0.0	0.0	0.0	0.0	0.0	7.92E-10	1.52E 00	5.91E 02	5.93E 02
9000.	0.0	1.52E 00	0.0	0.0	0.0	0.0	0.0	5.03E-06	2.40E 00	9.30E 02	9.32E 02
10000.	0.0	2.40E 00	0.0	0.0	0.0	0.0	0.0	3.85E 01	6.48E 01	1.16E 04	1.16E 04
20000.	0.0	2.68E 01	0.0	0.0	0.0	0.0	0.0	5.68E 01	8.58E 01	1.30E 04	1.31E 04
30000.	0.0	2.90E 01	0.0	0.0	0.0	0.0	0.0	9.05E 01	1.21E 02	1.46E 04	1.47E 04
40000.	0.0	3.03E 01	0.0	0.0	0.0	0.0	0.0	1.12E 02	1.43E 02	1.56E 04	1.57E 04
50000.	0.0	3.10E 01	0.0	0.0	0.0	0.0	0.0	1.19E 02	1.50E 02	1.59E 04	1.61E 04
60000.	0.0	3.14E 01	0.0	0.0	0.0	0.0	0.0	1.19E 02	1.50E 02	1.59E 04	1.61E 04
70000.	0.0	3.14E 01	0.0	0.0	0.0	0.0	0.0	1.17E 02	1.48E 02	1.58E 04	1.59E 04
80000.	0.0	3.12E 01	0.0	0.0	0.0	0.0	0.0	1.13E 02	1.44E 02	1.55E 04	1.56E 04
90000.	0.0	3.08E 01	0.0	0.0	0.0	0.0	0.0	1.10E 02	1.41E 02	1.52E 04	1.54E 04
100000.	0.0	3.04E 01	0.0	0.0	0.0	0.0	0.0	2.59E 02	3.39E 02	3.93E 04	3.96E 04
200000.	0.0	8.03E 01	0.0	0.0	0.0	0.0	0.0	3.19E 02	3.84E 02	3.56E 04	3.60E 04
300000.	0.0	6.55E 01	0.0	0.0	0.0	0.0	0.0	2.41E 02	2.89E 02	2.62E 04	2.65E 04
400000.	0.0	4.77E 01	0.0	0.0	0.0	0.0	0.0	1.71E 02	2.05E 02	1.86E 04	1.88E 04
500000.	0.0	3.39E 01	0.0	0.0	0.0	0.0	0.0	1.22E 02	1.46E 02	1.32E 04	1.33E 04
600000.	0.0	2.40E 01	0.0	0.0	0.0	0.0	0.0	8.75E 01	1.06E 02	9.37E 03	9.48E 03
700000.	0.0	1.90E 01	0.0	0.0	0.0	0.0	0.0	6.33E 01	1.04E 03	6.93E 03	7.97E 03
800000.	0.0	9.75E 02	0.0	0.0	0.0	0.0	0.0	4.63E 01	5.31E 04	1.51E 04	6.82E 04
900000.	0.0	5.30E 04	0.0	0.0	0.0	0.0	0.0	3.43E 01	6.57E 05	1.30E 05	7.88E 05
1000000.	0.0	6.57E 05	0.0	0.0	0.0	0.0	0.0	2.22E 03	7.14E 05	4.30E 05	1.14E 06
TOTAL	0.0	7.12E 05	0.0	0.0	0.0	0.0	0.0				

Appendix D

Table 5-1. (Case 50)

TABLE 5 - 1 : TOTAL UNDISCOUNTED DAMAGES FOR EACH ZONE FOR EACH TIME INTERVAL -:HIGH POPULATION

TIME	REPO	EDDY	REBD	NIDO	WTE	LEA	CHAV	REGB	TOT.ZONE	NON-SPEC	TTOTAL
0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
300.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
400.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
600.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
700.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
800.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
900.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1000.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2000.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3000.	0.0	2.50E-14	0.0	0.0	0.0	0.0	0.0	0.0	2.50E-14	3.42E-12	3.45E-12
4000.	0.0	6.69E-04	0.0	0.0	0.0	0.0	0.0	0.0	6.69E-04	9.17E-02	9.24E-02
5000.	0.0	7.53E 01	0.0	0.0	0.0	0.0	0.0	0.0	7.53E 01	1.03E 04	1.04E 04
6000.	0.0	1.90E 04	0.0	0.0	0.0	0.0	0.0	4.34E-29	1.90E 04	2.62E 06	2.63E 06
7000.	0.0	1.97E 05	0.0	0.0	0.0	0.0	0.0	1.87E-17	1.97E 05	2.70E 07	2.72E 07
8000.	0.0	5.80E 05	0.0	0.0	0.0	0.0	0.0	1.77E-09	5.80E 05	7.97E 07	8.02E 07
9000.	0.0	1.12E 06	0.0	0.0	0.0	0.0	0.0	5.81E-04	1.12E 06	1.54E 08	1.55E 08
10000.	0.0	1.76E 06	0.0	0.0	0.0	0.0	0.0	3.69E 00	1.76E 06	2.42E 08	2.44E 08
20000.	0.0	1.97E 07	0.0	0.0	0.0	0.0	0.0	2.79E 07	4.76E 07	3.01E 09	3.06E 09
30000.	0.0	2.13E 07	0.0	0.0	0.0	0.0	0.0	4.17E 07	6.30E 07	3.38E 09	3.45E 09
40000.	0.0	2.22E 07	0.0	0.0	0.0	0.0	0.0	6.65E 07	8.87E 07	3.79E 09	3.87E 09
50000.	0.0	2.27E 07	0.0	0.0	0.0	0.0	0.0	8.25E 07	1.05E 08	4.05E 09	4.15E 09
60000.	0.0	2.31E 07	0.0	0.0	0.0	0.0	0.0	8.73E 07	1.10E 08	4.14E 09	4.25E 09
70000.	0.0	2.31E 07	0.0	0.0	0.0	0.0	0.0	8.73E 07	1.10E 08	4.14E 09	4.25E 09
80000.	0.0	2.29E 07	0.0	0.0	0.0	0.0	0.0	8.55E 07	1.08E 08	4.11E 09	4.21E 09
90000.	0.0	2.26E 07	0.0	0.0	0.0	0.0	0.0	8.31E 07	1.06E 08	4.03E 09	4.14E 09
100000.	0.0	2.23E 07	0.0	0.0	0.0	0.0	0.0	8.10E 07	1.03E 08	3.96E 09	4.07E 09
200000.	0.0	5.88E 07	0.0	0.0	0.0	0.0	0.0	1.90E 08	2.48E 08	1.02E 10	1.05E 10
300000.	0.0	4.80E 07	0.0	0.0	0.0	0.0	0.0	2.34E 08	2.82E 08	9.25E 09	9.53E 09
400000.	0.0	3.50E 07	0.0	0.0	0.0	0.0	0.0	1.77E 08	2.12E 08	6.82E 09	7.04E 09
500000.	0.0	2.48E 07	0.0	0.0	0.0	0.0	0.0	1.26E 08	1.51E 08	4.84E 09	4.99E 09
600000.	0.0	1.76E 07	0.0	0.0	0.0	0.0	0.0	8.96E 07	1.07E 08	3.42E 09	3.53E 09
700000.	0.0	1.39E 07	0.0	0.0	0.0	0.0	0.0	6.42E 07	7.81E 07	2.44E 09	2.51E 09
800000.	0.0	7.15E 08	0.0	0.0	0.0	0.0	0.0	4.65E 07	7.61E 08	1.80E 09	2.56E 09
900000.	0.0	3.89E 10	0.0	0.0	0.0	0.0	0.0	3.40E 07	3.89E 10	3.94E 09	4.28E 10
1000000.	0.0	4.82E 11	0.0	0.0	0.0	0.0	0.0	2.51E 07	4.82E 11	3.39E 10	5.16E 11
TOTAL	0.0	5.22E 11	0.0	0.0	0.0	0.0	0.0	1.63E 09	5.24E 11	1.12E 11	6.35E 11

Appendix D

Table 5-2. (Case 50)

TABLE 5 - 2 : TOTAL UNDISCOUNTED DAMAGES FOR EACH ZONE FOR EACH TIME INTERVAL -. LOW POPULATION

TIME	REPO	EDDY	REBO	WIDO	WTE	LEA	CHAV	RIGB	TOT.ZONE	NON-SPEC	TTOTAL
0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
300.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
400.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
600.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
700.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
800.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
900.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1000.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2000.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3000.	0.0	8.86E-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4000.	0.0	2.37E-04	0.0	0.0	0.0	0.0	0.0	0.0	8.86E-15	3.42E-12	3.43E-12
5000.	0.0	2.67E 01	0.0	0.0	0.0	0.0	0.0	0.0	2.37E-04	9.17E-02	9.20E-02
6000.	0.0	6.75E 03	0.0	0.0	0.0	0.0	0.0	0.0	2.67E 01	1.03E 04	1.03E 04
7000.	0.0	6.97E 04	0.0	0.0	0.0	0.0	0.0	1.43E-29	6.75E 03	2.62E 06	2.62E 06
8000.	0.0	2.06E 05	0.0	0.0	0.0	0.0	0.0	6.64E-18	6.97E 04	2.70E 07	2.71E 07
9000.	0.0	3.96E 05	0.0	0.0	0.0	0.0	0.0	6.28E-10	2.06E 05	7.97E 07	7.99E 07
10000.	0.0	6.23E 05	0.0	0.0	0.0	0.0	0.0	2.06E-04	3.96E 05	1.54E 08	1.54E 08
20000.	0.0	6.98E 06	0.0	0.0	0.0	0.0	0.0	1.31E 00	6.23E 05	2.42E 08	2.42E 08
30000.	0.0	7.55E 06	0.0	0.0	0.0	0.0	0.0	9.88E 06	1.69E 07	3.01E 09	3.03E 09
40000.	0.0	7.89E 06	0.0	0.0	0.0	0.0	0.0	1.48E 07	2.23E 07	3.38E 09	3.41E 09
50000.	0.0	8.06E 06	0.0	0.0	0.0	0.0	0.0	2.35E 07	3.14E 07	3.79E 09	3.82E 09
60000.	0.0	8.18E 06	0.0	0.0	0.0	0.0	0.0	2.92E 07	3.73E 07	4.05E 09	4.09E 09
70000.	0.0	8.18E 06	0.0	0.0	0.0	0.0	0.0	3.09E 07	3.91E 07	4.14E 09	4.18E 09
80000.	0.0	8.12E 06	0.0	0.0	0.0	0.0	0.0	3.09E 07	3.91E 07	4.14E 09	4.18E 09
90000.	0.0	8.09E 06	0.0	0.0	0.0	0.0	0.0	3.03E 07	3.84E 07	4.11E 09	4.14E 09
100000.	0.0	7.89E 06	0.0	0.0	0.0	0.0	0.0	2.94E 07	3.74E 07	4.03E 09	4.07E 09
200000.	0.0	2.09E 07	0.0	0.0	0.0	0.0	0.0	2.87E 07	3.66E 07	3.96E 09	4.00E 09
300000.	0.0	1.70E 07	0.0	0.0	0.0	0.0	0.0	6.71E 07	8.80E 07	1.02E 10	1.03E 10
400000.	0.0	1.24E 07	0.0	0.0	0.0	0.0	0.0	8.29E 07	1.00E 08	9.25E 09	9.35E 09
500000.	0.0	8.89E 06	0.0	0.0	0.0	0.0	0.0	6.28E 07	7.52E 07	6.82E 09	6.90E 09
600000.	0.0	6.23E 06	0.0	0.0	0.0	0.0	0.0	4.46E 07	5.34E 07	4.84E 09	4.89E 09
700000.	0.0	4.94E 06	0.0	0.0	0.0	0.0	0.0	3.18E 07	3.80E 07	3.42E 09	3.46E 09
800000.	0.0	2.54E 08	0.0	0.0	0.0	0.0	0.0	2.27E 07	2.77E 07	2.44E 09	2.46E 09
900000.	0.0	1.38E 10	0.0	0.0	0.0	0.0	0.0	1.65E 07	2.70E 08	1.80E 09	2.07E 09
1000000.	0.0	1.71E 11	0.0	0.0	0.0	0.0	0.0	1.20E 07	1.38E 10	3.94E 09	1.77E 10
TOTAL	0.0	1.85E 11	0.0	0.0	0.0	0.0	0.0	8.91E 06	1.71E 11	3.39E 10	2.05E 11
								5.77E 08	1.86E 11	1.12E 11	2.97E 11

APPENDIX E

AMRAW-B OUTPUT FOR VOLCANIC EXPLOSION RELEASE TO AIR AT 1000 YEARS

This appendix contains output for the special terminal storage case, No. 32, involving the discrete volcanic explosion release to air at 1000 years. Calculations are based on the total of cancers and genetic effects.

1. Annual Damage Rates, by Zone and Total

   a. Table 1-1. Zonal and Total Damages for High Population Projection ($/y).

   b. Table 1-2. Zonal and Total Damages for Low Population Projection, ($/y).

2. Annual Damage Rates, by Nuclide, Total All Zones, and Nonspecific

   Tables 2-23 (1000 y), -27 (5000 y), -32 (10,000 y), -36 (50,000 y), -41 (10^5 y), -45 (5×10^5 y), -50 (10^6 y), ($/y).

3. Discounted Present Values of Damage Costs by Nuclide, and Total, Integrated Over 10^6 Years

   Table 3. Discounted Present Values ($), Discount Rate = 0.00%.

4. Number of Deaths per Time Interval

   a. Table 4-1. High Population Scenario: Number of Deaths per Time Interval (#/Δy).

   b. Table 4-2. Low Population Scenario: Number of Deaths per Time Interval (#/Δy).

5. Total Undiscounted Damages per Time Interval, by Zone

   a. Table 5-1. Total Undiscounted Damages for Each Zone for Each Time Interval - High Population ($/Δy).

b. Table 5-2. Total Undiscounted Damages for Each Zone for Each Time Interval - Low Population ($/Δy).

Appendix E

Table 1-1. (Case 32)

TABLE 1 - 1 : ZONAL AND TOTAL DAMAGES FOR HIGH POP. PROJECTION ($/YR)

TIME	REPC	EDDY	HODU	MIDO	WTEX	LFA	CHAV	REGS	TOTAL ZONE	NON-SPEC	TTOTAL
0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
300.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
400.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
600.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
700.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
800.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
900.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1000.	5.65E 07	1.31E 08	1.09E 08	1.05E 08	4.98E 07	3.81E 08	1.47E 08	3.60E 08	1.34E 09	2.66E 08	1.60E 09
2000.	3.34E 07	8.60E 07	7.24E 07	6.73E 07	3.18E 07	2.33E 08	1.02E 08	2.04E 08	8.34E 09	5.42E 06	8.39E 08
3000.	2.34E 07	5.70E 07	4.73E 07	4.73E 07	2.23E 07	1.65E 08	6.52E 07	1.31E 08	5.58E 08	3.85E 06	5.62E 08
4000.	2.02E 07	4.76E 07	3.93E 07	4.07E 07	1.92E 07	1.41E 08	5.45E 07	1.09E 08	4.72E 08	3.69E 06	4.76E 08
5000.	1.80E 07	4.17E 07	3.51E 07	3.62E 07	1.71E 07	1.26E 08	4.77E 07	9.53E 07	4.17E 08	3.75E 06	4.21E 08
6000.	1.62E 07	3.72E 07	3.13E 07	3.27E 07	1.54E 07	1.14E 08	4.25E 07	8.52E 07	3.74E 08	3.92E 06	3.78E 08
7000.	1.47E 07	3.35E 07	2.82E 07	2.97E 07	1.40E 07	1.03E 08	3.81E 07	7.70E 07	3.38E 08	4.13E 06	3.42E 08
8000.	1.34E 07	2.99E 07	2.55E 07	2.70E 07	1.28E 07	9.40E 07	3.42E 07	7.00E 07	3.07E 08	4.35E 06	3.11E 08
9000.	1.23E 07	2.72E 07	2.31E 07	2.49E 07	1.17E 07	8.60E 07	3.11E 07	6.40E 07	2.80E 08	4.59E 06	2.85E 08
10000.	1.12E 07	2.47E 07	2.11E 07	2.27E 07	1.07E 07	7.89E 07	2.82E 07	5.86E 07	2.56E 08	4.85E 06	2.61E 08
20000.	7.47E 06	1.53E 07	1.36E 07	1.51E 07	7.11E 06	5.25E 07	1.81E 07	3.90E 07	1.69E 08	6.21E 06	1.75E 08
30000.	3.40E 06	6.41E 06	5.71E 06	6.86E 06	3.24E 06	2.39E 07	7.33E 06	1.77E 07	7.46E 07	7.74E 06	8.23E 07
40000.	1.71E 06	2.85E 06	2.64E 06	3.45E 06	1.63E 06	1.20E 07	3.26E 06	8.93E 06	3.65E 07	8.17E 06	4.47E 07
50000.	9.79E 05	1.56E 06	1.46E 06	1.98E 06	9.32E 05	6.88E 06	1.78E 06	5.10E 06	2.07E 07	7.88E 06	2.85E 07
60000.	5.97E 05	9.97E 05	9.23E 05	1.20E 06	5.68E 05	4.20E 06	1.14E 06	3.11E 06	1.27E 07	7.19E 06	1.99E 07
70000.	3.74E 05	7.00E 05	6.24E 05	7.54E 05	3.56E 05	2.63E 06	8.00E 05	1.95E 06	8.18E 06	6.38E 06	1.46E 07
80000.	2.37E 05	5.12E 05	4.39E 05	4.77E 05	2.25E 05	1.66E 06	5.06E 05	1.24E 06	5.27E 06	5.50E 06	1.09E 07
90000.	1.52E 05	3.85E 05	3.17E 05	3.07E 05	1.45E 05	1.07E 06	4.41E 05	7.93E 05	3.61E 06	4.07E 06	8.28E 06
100000.	9.58E 04	2.90E 05	2.35E 05	2.01E 05	9.52E 04	7.01E 05	3.39E 05	5.21E 05	2.49E 06	3.92E 06	6.41E 06
200000.	2.16E 04	8.42E 04	6.34E 04	4.36E 04	2.06E 04	1.52E 05	9.64E 04	1.13E 05	5.95E 05	1.24E 06	1.84E 06
300000.	1.86E 03	8.48E 03	6.23E 03	3.76E 03	1.78E 03	1.31E 04	9.72E 03	9.73E 03	5.46E 04	1.30E 05	1.85E 05
400000.	2.04E 02	7.98E 02	6.03E 02	4.11E 02	1.94E 02	1.43E 03	9.13E 02	1.06E 03	5.62E 03	1.15E 04	1.71E 04
500000.	2.15E 01	7.15E 01	5.53E 01	4.28E 01	2.02E 01	1.49E 02	8.18E 01	1.11E 02	5.53E 02	9.48E 02	1.50E 03
600000.	2.14E 00	6.34E 00	5.03E 00	4.32E 00	2.04E 00	1.51E 01	7.24E 00	1.12E 01	5.34E 01	7.66E 01	1.30E 02
700000.	2.13E-01	5.61E-01	4.57E-01	4.30E-01	2.03E-01	1.49E 00	6.41E-01	1.11E 00	5.11E 00	6.15E 00	1.13E 01
800000.	2.09E-02	5.01E-02	4.13E-02	4.21E-02	1.99E-02	1.47E-01	5.73E-02	1.09E-01	4.88E-01	4.96E-01	9.83E-01
900000.	2.03E-03	4.51E-03	3.83E-03	4.10E-03	1.93E-03	1.43E-02	5.15E-03	1.06E-02	4.64E-02	4.04E-02	8.68E-02
1000000.	1.96E-04	4.04E-04	3.54E-04	3.96E-04	1.87E-04	1.38E-03	4.68E-04	1.03E-03	4.42E-03	3.30E-03	7.72E-03

Appendix E

Table 1-2. (Case 32)

TABLE 1 - 2 : ZONAL AND TOTAL DAMAGES FOR LO. POP. PROJECTION ($/YR)

TIME	HEPO	EDDY	NPCB	MIDO	WTEX	LEA	CHAV	WEGB	TOT.ZONE	NON-SPEC	TTOTAL
0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
300.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
400.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
600.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
700.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
800.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
900.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1000.	5.65E 07	4.64E 07	2.73E 07	2.99E 07	1.53E 07	1.15E 06	3.94E 07	1.28E 08	4.55E 08	2.00E 08	7.22E 08
2000.	3.34E 07	3.15E 07	1.82E 07	1.92E 07	8.47E 06	7.08E 07	2.73E 07	7.22E 07	2.81E 08	5.42E 06	2.67E 08
3000.	2.34E 07	2.32E 07	1.19E 07	1.35E 07	5.96E 06	4.97E 07	1.75E 07	4.64E 07	1.82E 08	3.85E 06	1.93E 08
4000.	2.02E 07	1.69E 07	1.09E 07	1.10E 07	5.12E 06	4.27E 07	1.46E 07	3.85E 07	1.60E 08	3.09E 06	1.63E 08
5000.	1.80E 07	1.40E 07	8.33E 06	1.04E 07	4.57E 06	3.82E 07	1.28E 07	3.37E 07	1.41E 08	2.75E 06	1.45E 08
6000.	1.62E 07	1.31E 07	7.93E 06	9.35E 06	4.12E 06	3.44E 07	1.14E 07	3.02E 07	1.27E 08	2.47E 06	1.31E 08
7000.	1.47E 07	1.13E 07	7.59E 06	8.40E 06	3.73E 06	3.12E 07	1.02E 07	2.73E 07	1.15E 08	2.13E 06	1.19E 08
8000.	1.34E 07	1.06E 07	6.41E 06	7.71E 06	3.40E 06	2.84E 07	9.19E 06	2.48E 07	1.04E 08	2.35E 06	1.08E 08
9000.	1.22E 07	9.04E 06	5.81E 06	7.07E 06	3.11E 06	2.60E 07	8.33E 06	2.27E 07	9.49E 07	2.05E 06	9.55E 07
10000.	1.16E 07	8.77E 05	5.30E 06	6.48E 06	2.86E 06	2.38E 07	7.57E 06	2.08E 07	8.64E 07	2.05E 06	9.17E 07
20000.	7.47E 06	5.67E 06	3.43E 06	4.31E 06	1.90E 06	1.59E 07	4.84E 06	1.38E 07	5.72E 07	6.21E 05	6.34E 07
30000.	3.40E 06	2.27E 05	1.44E 06	1.96E 06	8.64E 05	7.22E 06	1.96E 06	8.20E 06	2.54E 07	7.71E 06	3.31E 07
40000.	1.71E 06	1.01E 06	6.65E 05	9.87E 05	4.35E 05	3.63E 06	8.74E 05	3.10E 06	1.25E 07	8.17E 06	2.06E 07
50000.	9.79E 05	5.52E 05	3.60E 05	5.65E 05	2.49E 05	2.06E 06	4.77E 05	1.81E 06	7.07E 06	7.60E 06	1.49E 07
60000.	5.97E 05	3.55E 05	2.22E 05	3.44E 05	1.52E 05	1.27E 06	3.06E 05	1.10E 06	4.35E 06	7.19E 06	1.15E 07
70000.	3.74E 05	2.45E 05	1.57E 05	2.18E 05	9.50E 04	7.93E 05	2.14E 05	6.91E 05	2.79E 06	6.66E 06	9.17E 06
80000.	2.37E 05	1.62E 05	1.13E 05	1.36E 05	6.01E 04	5.02E 05	1.57E 05	4.33E 05	1.82E 06	5.50E 06	7.32E 06
90000.	1.55E 05	1.27E 05	7.97E 04	8.70E 04	3.80E 04	3.22E 05	1.18E 05	2.81E 05	1.22E 06	4.67E 06	5.89E 06
100000.	9.98E 04	1.05E 05	5.91E 04	5.75E 04	2.54E 04	2.12E 05	9.07E 04	1.84E 05	8.34E 05	3.92E 06	4.75E 06
200000.	2.16E 04	2.90E 04	1.60E 04	1.24E 04	5.49E 03	4.59E 04	2.58E 04	4.00E 04	1.57E 05	1.24E 06	1.44E 06
300000.	1.86E 03	3.91E 03	1.57E 03	1.03E 03	4.74E 02	3.95E 03	3.45E 03	3.60E 03	1.30E 05	1.38E 05	1.48E 05
400000.	2.04E 02	2.82E 02	1.51E 02	1.17E 02	5.18E 01	4.32E 02	2.45E 02	3.77E 02	1.66E 03	1.15E 04	1.33E 04
500000.	2.12E 01	2.54E 01	1.32E 01	1.22E 01	5.39E 00	4.50E 01	2.19E 01	3.92E 01	1.44E 02	9.40E 02	1.13E 03
600000.	2.14E 00	2.23E 00	1.20E 00	1.24E 00	5.45E-01	4.55E 00	1.94E 00	3.96E 00	1.75E 01	7.00E 01	9.45E 01
700000.	2.13E-01	1.99E-01	1.15E-01	1.23E-01	5.40E-02	4.51E-01	1.72E-01	3.93E-01	1.72E 00	6.13E 00	7.87E 00
800000.	2.09E-02	1.78E-02	1.03E-02	1.20E-02	5.30E-03	4.43E-02	1.54E-02	3.86E-02	1.65E-01	4.90E-01	6.61E-01
900000.	2.03E-03	1.58E-03	9.65E-04	1.17E-03	5.15E-04	4.30E-03	1.38E-03	3.75E-03	1.57E-02	4.04E-02	5.61E-02
1000000.	1.96E-04	1.45E-04	8.91E-05	1.13E-04	4.99E-05	4.17E-04	1.25E-04	3.63E-04	1.50E-03	3.30E-03	4.80E-03

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Table 2-23. (Case 32) Annual Damage Rates by Nuclide

TABLE 2 - 23 : TIME PERIOD= 1000.

NUCLIDE	HIGH POP	LOW POP	NON-SPEC	TOT-HIGH	TOT-LOW
C-14	9.77E 02	3.09E 02	7.77E 03	8.74E 03	8.07E 03
SR-90	1.16E 01	3.66E 00	1.33E 01	2.49E 01	1.70E 01
Y-90	9.63E-02	3.03E-02	4.98E-02	1.46E-01	8.01E-02
ZR-93	4.56E 02	1.48E 02	1.46E 03	1.91E 03	1.60E 03
NB-93M	7.43E 02	2.38E 02	1.72E 04	1.80E 04	1.75E 04
TC-99	1.10E 04	3.51E 03	4.47E 05	4.58E 05	4.51E 05
I-129	1.75E 00	5.48E-01	1.35E 00	3.10E 00	1.95E 00
CS-135	2.16E 03	6.79E 02	1.55E 04	1.77E 04	1.62E 04
CS-137	3.20E 00	1.04E 00	2.07E 01	2.40E 01	2.10E 01
PU-210	1.44E 03	4.64E 02	1.24E 03	2.69E 03	1.71E 03
RA-225	2.74E 03	8.81E 02	1.99E 04	2.22E 04	2.04E 04
RA-226	1.30E 04	4.10E 03	1.14E 05	1.27E 05	1.18E 05
TH-229	7.83E 04	2.62E 04	2.65E 03	7.82E 04	2.90E 04
TH-230	1.62E 04	5.66E 03	3.40E 02	1.66E 04	6.01E 03
NP-237	2.36E 06	7.99E 05	5.74E 05	2.94E 06	1.37E 06
NP-239	8.47E 06	2.94E 06	1.15E 04	8.48E 06	2.95E 06
PU-238	5.48E 06	1.91E 06	5.75E 04	5.54E 06	1.97E 06
PU-239	1.93E 07	6.74E 06	2.12E 05	1.95E 07	6.95E 06
PU-240	2.10E 03	7.00E 07	2.39E 06	2.20E 08	7.04E 07
PU-241	2.42E 05	8.43E 04	3.50E 03	2.46E 05	8.80E 04
AM-241	6.13E 08	2.07E 08	1.46E 08	7.60E 08	3.55E 08
AM-242M	2.98E 06	1.00E 06	7.92E 05	3.77E 06	1.80E 06
AM-243	4.69E 08	1.59E 08	1.14E 08	5.83E 08	2.73E 08
CM-242	1.59E 05	5.48E 04	1.31E 04	1.72E 05	6.79E 04
CM-244	7.27E-05	2.47E-05	1.48E-05	8.75E-05	3.95E-05

Table 2-27. (Case 32) Annual Damage Rates by Nuclide

TABLE 2 - 27 : TIME PERIOD= 5000.

NUCLIDE	HIGH POP	LOW POP	NON-SPEC	TOT-HIGH	TOT-LOW
C-14	4.23E 02	1.27E 02	3.98E 03	4.40E 03	4.11E 03
SR-90	0.0	0.0	0.0	0.0	0.0
Y-90	0.0	0.0	0.0	0.0	0.0
ZR-93	3.14E 02	9.93E 01	8.02E 02	1.12E 03	9.01E 02
NB-93M	5.00E 02	1.55E 02	1.35E 04	1.40E 04	1.36E 04
TC-99	7.33E 03	2.24E 03	3.77E 05	3.84E 05	3.79E 05
I-129	1.55E 00	5.32E-01	5.78E-01	2.13E 00	1.11E 00
CS-135	1.43E 03	4.25E 02	9.73E 03	1.12E 04	1.02E 04
CS-137	0.0	0.0	0.0	0.0	0.0
PU-210	1.76E 04	5.42E 03	4.95E 03	2.25E 04	1.04E 04
RA-225	8.33E 03	2.49E 03	6.79E 04	7.62E 04	7.04E 04
RA-226	1.54E 05	4.60E 04	1.26E 06	1.42E 06	1.31E 06
TH-229	2.62E 05	9.04E 04	3.00E 02	2.62E 05	9.07E 04
TH-230	6.46E 04	2.24E 04	4.15E 01	6.47E 04	2.24E 04
NP-237	1.81E 06	6.04E 05	1.38E 04	1.83E 06	6.18E 05
NP-239	5.64E 06	1.96E 06	1.10E 03	5.64E 06	1.96E 06
PU-238	9.86E-01	3.42E-01	3.30E-06	9.86E-01	3.42E-01
PU-239	3.33E 07	1.15E 07	1.16E 03	3.33E 07	1.15E 07
PU-240	1.14E 08	3.95E 07	3.99E 03	1.14E 08	3.95E 07
PU-241	1.37E 05	4.74E 04	6.43E 02	1.37E 05	4.74E 04
AM-241	1.86E 07	6.21E 06	1.41E 05	1.88E 07	6.35E 06
AM-242M	7.60E-01	2.52E-01	5.88E-03	7.66E-01	2.38E-01
AM-243	2.44E 08	8.12E 07	1.85E 06	2.46E 08	8.31E 07
CM-242	3.86E-02	1.32E-02	1.05E-04	3.87E-02	1.33E-02
CM-244	0.0	0.0	0.0	0.0	0.0

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Table 2-32. (Case 32) Annual Damage Rates by Nuclide

TABLE 2 - 32 : TIME PERIOD= 10000.

NUCLIDE	HIGH POP	LOW POP	NON-SPEC	TOT-HIGH	TOT-LOW
C-14	2.01E 02	6.02E 01	1.92E 03	2.12E 03	1.98E 03
SR-90	0.0	0.0	0.0	0.0	0.0
Y-90	0.0	0.0	0.0	0.0	0.0
ZR-93	2.73E 02	8.63E 01	7.09E 02	9.83E 02	7.96E 02
NB-93M	4.37E 02	1.35E 02	1.20E 04	1.24E 04	1.21E 04
TC-99	6.29E 03	1.92E 03	3.29E 05	3.35E 05	3.31E 05
I-129	1.38E 00	4.73E-01	5.07E-01	1.89E 00	9.80E-01
CS-135	1.24E 03	3.67E 02	8.53E 03	9.76E 03	8.89E 03
CS-137	0.0	0.0	0.0	0.0	0.0
PB-210	4.45E 04	1.37E 04	1.26E 04	5.72E 04	2.64E 04
RA-225	1.47E 04	4.38E 03	1.22E 05	1.37E 05	1.26E 05
RA-226	3.87E 05	1.15E 05	3.22E 06	3.61E 06	3.34E 06
TH-229	4.75E 05	1.64E 05	5.45E 02	4.78E 05	1.65E 05
TH-230	1.20E 05	4.17E 04	7.71E 01	1.20E 05	4.17E 04
NP-237	1.61E 06	3.38E 05	1.23E 04	1.63E 06	3.50E 05
NP-239	3.22E 06	1.12E 06	6.27E 02	3.22E 06	1.12E 06
PU-238	1.01E-10	3.50E-11	3.36E-15	1.01E-10	3.50E-11
PU-239	4.23E 07	1.47E 07	1.47E 03	4.23E 07	1.47E 07
PU-240	6.11E 07	2.12E 07	2.12E 03	6.11E 07	2.12E 07
PU-241	7.97E 04	2.76E 04	3.72E 00	7.97E 04	2.77E 04
AM-241	8.59E 06	2.86E 06	6.54E 04	8.66E 06	2.93E 06
AM-242M	7.12E-11	2.36E-11	6.00E-13	7.18E-11	2.42E-11
AM-243	1.38E 08	4.60E 07	1.06E 06	1.39E 08	4.71E 07
CM-242	3.94E-12	1.35E-12	1.07E-14	3.95E-12	1.36E-12
CM-244	0.0	0.0	0.0	0.0	0.0

Table 2-36. (Case 32) Annual Damage Rates by Nuclide

TABLE 2 - 36 : TIME PERIOD= 50000.

NUCLIDE	HIGH POP	LOW POP	NON-SPEC	TOT-HIGH	TOT-LOW
C-14	1.34E 00	4.03E-01	1.28E 01	1.42E 01	1.32E 01
SR-90	0.0	0.0	0.0	0.0	0.0
Y-90	0.0	0.0	0.0	0.0	0.0
ZR-93	1.19E 02	3.75E 01	3.09E 02	4.27E 02	3.46E 02
NB-93M	1.91E 02	5.87E 01	5.24E 03	5.43E 03	5.30E 03
TC-99	2.46E 03	7.50E 02	1.28E 05	1.31E 05	1.29E 05
I-129	6.10E-01	2.09E-01	2.24E-01	8.34E-01	4.33E-01
CS-135	5.41E 02	1.60E 02	3.73E 03	4.27E 03	3.89E 03
CS-137	0.0	0.0	0.0	0.0	0.0
PB-210	1.03E 05	3.19E 04	2.92E 04	1.33E 05	6.11E 04
RA-225	2.66E 04	7.91E 03	2.20E 05	2.47E 05	2.23E 05
RA-226	8.96E 05	2.66E 05	7.46E 06	8.36E 06	7.73E 06
TH-229	8.57E 05	2.96E 05	9.82E 02	8.58E 05	2.97E 05
TH-230	2.08E 05	7.20E 04	1.33E 02	2.08E 05	7.22E 04
NP-237	7.20E 05	2.40E 05	5.50E 03	7.26E 05	2.46E 05
NP-239	9.24E 04	1.82E 04	1.02E 01	9.24E 04	1.82E 04
PU-238	0.0	0.0	0.0	0.0	0.0
PU-239	1.46E 07	5.05E 06	5.06E 02	1.46E 07	5.05E 06
PU-240	7.50E 05	2.60E 05	2.60E 01	7.50E 05	2.60E 05
PU-241	2.16E 03	7.48E 02	1.00E-01	2.16E 03	7.48E 02
AM-241	2.30E 05	7.67E 04	1.75E 03	2.32E 05	7.85E 04
AM-242M	0.0	0.0	0.0	0.0	0.0
AM-243	2.25E 06	7.53E 05	1.72E 04	2.27E 06	7.67E 05
CM-242	0.0	0.0	0.0	0.0	0.0
CM-244	0.0	0.0	0.0	0.0	0.0

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Table 2-41. (Case 32) Annual Damage Rates by Nuclide

TABLE 2 - 41 : TIME PERIOD= 100000.

NUCLIDE	HIGH POP	LOW POP	NON-SPEC	TOT-HIGH	TOT-LOW
C-14	1.01E-03	3.04E-04	9.69E-03	1.07E-02	9.99E-03
SR-90	0.0	0.0	0.0	0.0	0.0
Y-90	0.0	0.0	0.0	0.0	0.0
ZR-93	3.69E 01	1.17E 01	9.59E 01	1.33E 02	1.08E 02
NB-93M	5.89E 01	1.81E 01	1.62E 03	1.67E 03	1.03E 03
TC-99	6.65E 02	2.02E 02	3.48E 04	3.54E 04	3.50E 04
I-129	1.93E-01	4.60E-02	7.07E-02	2.63E-01	1.37E-01
CS-135	1.70E 02	5.92E 01	1.17E 03	1.34E 03	1.22E 03
CS-137	0.0	0.0	0.0	0.0	0.0
PB-210	5.16E 04	1.59E 04	1.48E 04	6.62E 04	3.05E 04
RA-225	1.57E 04	4.67E 03	1.30E 05	1.46E 05	1.35E 05
RA-226	4.48E 05	1.33E 05	3.73E 06	4.18E 06	3.87E 06
TH-229	5.06E 05	1.75E 05	5.80E 02	5.07E 05	1.75E 05
TH-230	1.06E 03	3.67E 04	6.79E 01	1.06E 05	3.68E 04
NP-237	2.24E 05	7.45E 04	1.71E 03	2.25E 05	7.62E 04
NP-239	1.95E 02	6.77E 01	3.74E-02	1.95E 02	6.78E 01
PU-238	0.0	0.0	0.0	0.0	0.0
PU-239	1.13E 06	3.91E 05	3.92E 01	1.13E 06	3.91E 05
PU-240	1.43E 03	4.96E 02	4.97E-02	1.43E 03	4.96E 02
PU-241	9.77E 00	3.39E 00	4.56E-04	9.77E 00	3.29E 00
AM-241	1.05E 03	3.48E 02	7.94E 00	1.05E 03	3.50E 02
AM-242M	0.0	0.0	0.0	0.0	0.0
AM-243	8.37E 03	2.79E 03	6.40E 01	8.43E 03	2.85E 03
CM-242	0.0	0.0	0.0	0.0	0.0
CM-244	0.0	0.0	0.0	0.0	0.0

Table 2-45. (Case 32) Annual Damage Rates by Nuclide

TABLE 2 - 45 : TIME PERIOD= 500000.

NUCLIDE	HIGH POP	LOW POP	NON-SPEC	TOT-HIGH	TOT-LOW
C-14	4.67E-24	1.40E-24	4.45E-23	4.92E-23	4.59E-23
SR-90	0.0	0.0	0.0	0.0	0.0
Y-90	0.0	0.0	0.0	0.0	0.0
ZR-93	8.86E-03	2.80E-03	2.30E-02	3.18E-02	2.58E-02
NB-93M	1.39E-02	4.29E-03	3.62E-01	3.96E-01	3.86E-01
TC-99	5.80E-02	1.77E-02	3.04E 00	3.09E 00	3.05E 00
I-129	5.40E-05	1.85E-05	1.68E-05	7.39E-05	3.83E-05
CS-135	4.43E-02	1.31E-02	3.06E-01	3.50E-01	3.19E-01
CS-137	0.0	0.0	0.0	0.0	0.0
PB-210	1.13E 01	3.64E 00	3.33E 00	1.52E 01	6.98E 00
RA-225	1.08E 01	3.20E 00	8.91E 01	9.98E 01	9.23E 01
RA-226	1.02E 02	3.03E 01	8.51E 02	9.53E 02	8.81E 02
TH-229	3.47E 02	1.20E 02	3.98E-01	3.47E 02	1.20E 02
TH-230	2.42E 01	8.37E 00	1.55E-02	2.42E 01	8.39E 00
NP-237	5.68E 01	1.89E 01	4.34E-01	5.72E 01	1.93E 01
NP-239	3.63E-06	1.26E-06	7.06E-10	3.63E-06	1.26E-06
PU-238	0.0	0.0	0.0	0.0	0.0
PU-239	9.11E-02	3.16E-02	3.17E-06	9.11E-02	3.16E-02
PU-240	3.83E-07	1.33E-07	1.33E-11	3.83E-07	1.33E-07
PU-241	3.22E-14	1.12E-14	1.50E-18	3.22E-14	1.12E-14
AM-241	3.76E-12	1.25E-12	2.80E-14	3.76E-12	1.28E-12
AM-242M	0.0	0.0	0.0	0.0	0.0
AM-243	1.55E-04	5.17E-05	1.19E-06	1.56E-04	5.29E-05
CM-242	0.0	0.0	0.0	0.0	0.0
CM-244	0.0	0.0	0.0	0.0	0.0

Appendix E

Table 2-50. (Case 32) Annual Damage Rates by Nuclide

TABLE 2 - 50 : TIME PERIOD= 1000000.

NUCLIDE	HIGH POP	LOW POP	NON-SPEC	TOT-HIGH	TOT-LOW
C-14	0.0	0.0	0.0	0.0	0.0
SR-90	0.0	0.0	0.0	0.0	0.0
Y-90	0.0	0.0	0.0	0.0	0.0
ZR-93	7.14E-08	2.25E-08	1.85E-07	2.57E-07	2.09E-07
NB-93M	1.14E-07	3.50E-08	3.12E-06	3.24E-06	3.16E-06
TC-99	1.17E-07	3.59E-08	6.10E-06	6.22E-06	6.14E-06
I-129	5.37E-10	1.84E-10	1.97E-10	7.33E-10	3.80E-10
CS-135	4.00E-07	1.19E-07	2.76E-06	3.16E-06	2.88E-06
CS-137	0.0	0.0	0.0	0.0	0.0
PB-210	3.32E-05	1.02E-05	9.36E-06	4.26E-05	1.94E-05
RA-225	1.06E-04	3.16E-05	8.02E-06	9.09E-04	9.14E-04
RA-226	2.87E-04	8.53E-05	2.34E-03	2.68E-03	2.40E-03
TH-229	3.43E-03	1.18E-03	3.93E-06	3.43E-03	1.19E-03
TH-230	8.81E-05	2.36E-05	4.36E-08	6.82E-05	2.36E-05
NP-237	4.90E-04	1.63E-04	3.75E-06	4.94E-04	1.67E-04
NP-239	1.21E-13	4.21E-11	2.36E-14	1.21E-10	4.21E-11
PU-238	0.0	0.0	0.0	0.0	0.0
PU-239	6.83E-09	2.37E-09	2.37E-13	6.83E-09	2.37E-09
PU-240	4.1[illegible]E-11	1.44E-11	1.45E-15	4.18E-11	1.44E-11
PU-241	1.89E-31	6.59E-32	7.48E-36	1.89E-31	6.55E-32
AM-241	2.24E-29	7.67E-30	1.05E-31	2.26E-29	7.85E-30
AM-242M	0.0	0.0	0.0	0.0	0.0
AM-243	5.06E-09	1.68E-09	3.07E-11	5.10E-09	1.72E-09
CM-242	0.0	0.0	0.0	0.0	0.0
CM-244	0.0	0.0	0.0	0.0	0.0

Appendix E

Table 3. (Case 32)

TABLE 3 : DISCOUNTED PRESENT VALUES ($)
DISCOUNT RATE = 0.00 %

NUCLIDE	HIGH POPULATION DISCOUNTED	HIGH POPULATION PV $/GM	LOW POPULATION DISCOUNTED	LOW POPULATION PV $/GM
PU-240	0.15E 13		0.51E 12	
CM-244	0.98E-02		0.43E-02	
SUB TOT	1.46E 12	3.35E 04	5.08E 11	1.16E 04
RA-225	0.26E 11		0.24E 11	
TH-229	0.90E 11		0.31E 11	
NP-237	0.85E 11		0.29E 11	
PU-241	0.19E 10		0.66E 09	
AM-241	0.59E 12		0.21E 12	
SUB TOT	7.96E 11	7.68E 03	2.95E 11	2.85E 03
PB-210	0.12E 11		0.56E 10	
RA-226	0.76E 12		0.71E 12	
TH-230	0.20E 11		0.68E 10	
PU-238	0.22E 10		0.78E 09	
AM-242M	0.14E 10		0.51E 09	
CM-242	0.69E 08		0.25E 08	
SUB TOT	7.98E 11	1.23E 05	7.19E 11	1.11E 05
NP-239	0.77E 11		0.27E 11	
PU-239	0.16E 13		0.56E 12	
AM-243	0.34E 13		0.12E 13	
SUB TOT	5.07E 12	6.37E 04	1.74E 12	2.18E 04
C-14	0.53E 08		0.50E 08	
SUB TOT	5.35E 07	1.32E 03	4.98E 07	1.23E 03
SR-90	0.34E 04		0.22E 04	
Y-90	0.23E 02		0.12E 02	
SUB TOT	3.46E 03	5.51E-05	2.20E 03	3.51E-05
ZR-93	0.50E 08		0.41E 08	
NB-93M	0.64E 09		0.62E 09	
SUB TOT	6.88E 08	5.17E 00	6.63E 08	4.98E 00
TC-99	0.16E 11		0.15E 11	
SUB TOT	1.57E 10	1.02E 02	1.55E 10	1.01E 02
I-129	0.98E 05		0.51E 05	
SUB TOT	9.81E 04	1.68E 00	5.10E 04	8.73E-01
CS-135	0.51E 09		0.46E 09	
SUB TOT	5.06E 08	7.44E 00	4.61E 08	6.77E 00
CS-137	0.39E 04		0.35E 04	
SUB TOT	3.87E 03	2.55E-05	3.50E 03	2.30E-05
TOTAL	8.15E 12	1.01E 04	3.28E 12	4.08E 03

Appendix E

Table 4-1. (Case 32)

TABLE 4 - 1.1 HIGH POPULATION SCENARIO
NUMBER OF DEATHS PER TIME INTERVAL (1920000.)

TIME	HFPO	EDDY	HEIRO	MIDO	WTE	LEA	CHAV	HESS	TOT.ZONE	NON-SPEC	TTOTAL
0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
300.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
400.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
600.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
700.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
800.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
900.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1000.	2.17E 04	5.34E 04	4.18E 04	4.02E 04	1.91E 04	1.46E 05	5.65E 04	1.38E 05	5.15E 05	1.02E 05	6.17E 05
2000.	1.28E 05	3.42E 05	2.78E 05	2.54E 05	1.22E 05	9.02E 05	3.91E 05	7.84E 05	3.21E 06	2.08E 04	3.23E 06
3000.	9.01E 04	2.15E 05	1.82E 05	1.82E 05	8.50E 04	6.33E 05	2.51E 05	5.04E 05	2.15E 06	1.48E 04	2.16E 06
4000.	7.75E 04	1.83E 05	1.53E 05	1.56E 05	7.38E 04	5.44E 05	2.10E 05	4.18E 05	1.82E 06	1.42E 04	1.83E 06
5000.	6.92E 04	1.61E 05	1.35E 05	1.39E 05	6.58E 04	4.86E 05	1.83E 05	3.66E 05	1.61E 06	1.44E 04	1.62E 06
6000.	6.24E 04	1.43E 05	1.21E 05	1.26E 05	5.93E 04	4.38E 05	1.64E 05	3.28E 05	1.44E 06	1.51E 04	1.46E 06
7000.	5.68E 04	1.28E 05	1.08E 05	1.14E 05	5.38E 04	3.98E 05	1.48E 05	2.98E 05	1.30E 06	1.35E 04	1.32E 06
8000.	5.19E 04	1.15E 05	9.79E 04	1.04E 05	4.90E 04	3.61E 05	1.32E 05	2.69E 05	1.18E 06	1.67E 04	1.20E 06
9000.	4.71E 04	1.05E 05	8.89E 04	9.52E 04	4.49E 04	3.31E 05	1.20E 05	2.46E 05	1.08E 06	1.77E 04	1.09E 06
10000.	4.32E 04	9.51E 04	8.10E 04	8.72E 04	4.12E 04	3.03E 05	1.09E 05	2.26E 05	9.85E 05	1.86E 04	1.00E 06
20000.	2.87E 05	6.09E 05	5.24E 05	5.80E 05	2.74E 05	2.02E 06	6.94E 05	1.50E 06	6.49E 06	2.35E 05	6.73E 06
30000.	1.31E 05	2.46E 05	2.29E 05	2.64E 05	1.25E 05	9.19E 05	2.82E 05	6.82E 05	2.87E 06	2.70E 05	3.16E 06
40000.	6.59E 04	1.10E 05	1.02E 05	1.33E 05	6.27E 04	4.63E 05	1.25E 05	3.44E 05	1.49E 06	3.14E 05	1.72E 06
50000.	3.78E 04	5.95E 04	5.63E 04	7.01E 04	3.54E 04	2.64E 05	6.84E 04	1.96E 05	7.55E 05	3.03E 05	1.10E 06
60000.	2.30E 04	3.04E 04	3.55E 04	4.63E 04	2.18E 04	1.61E 05	4.34E 04	1.20E 05	4.50E 05	2.77E 05	7.67E 05
70000.	1.44E 04	2.09E 04	2.40E 04	2.96E 04	1.37E 04	1.01E 05	3.08E 04	7.50E 04	3.15E 05	2.45E 05	5.60E 05
80000.	9.12E 03	1.97E 04	1.69E 04	3.84E 04	8.66E 03	6.40E 04	2.25E 04	4.75E 04	2.07E 05	2.11E 05	4.18E 05
90000.	5.80E 03	1.48E 04	1.22E 04	1.18E 04	5.58E 03	4.11E 04	1.70E 04	3.05E 04	1.39E 05	1.80E 05	3.18E 05
100000.	3.84E 03	1.14E 04	9.04E 03	7.75E 03	3.66E 03	2.70E 04	1.30E 04	2.00E 04	9.57E 04	1.51E 05	2.46E 05
200000.	6.33E 03	3.24E 04	2.44E 04	1.68E 04	7.92E 03	5.85E 04	3.71E 04	4.35E 04	2.24E 05	4.78E 05	7.06E 05
300000.	7.15E 02	3.26E 03	2.40E 03	1.45E 03	6.83E 02	5.03E 03	3.74E 03	3.74E 03	2.10E 04	5.00E 04	7.10E 04
400000.	7.66E 01	3.97E 02	2.31E 02	1.58E 02	7.47E 01	5.51E 02	3.51E 02	4.09E 02	2.16E 03	4.41E 03	6.57E 03
500000.	8.18E 00	5.75E 01	2.12E 01	1.65E 01	7.78E 00	5.74E 01	3.15E 01	4.26E 01	2.13E 02	3.05E 02	5.77E 02
600000.	8.23E-01	2.44E 00	1.93E 00	1.60E 00	7.65E-01	5.60E 00	2.78E 00	4.30E 00	2.05E 01	2.95E 01	5.00E 01
700000.	8.20E-02	2.16E-01	1.78E-01	1.65E-01	7.74E-02	5.75E-01	2.47E-01	4.27E-01	1.97E 00	2.37E 00	4.33E 00
800000.	8.04E-03	1.93E-02	1.61E-02	1.82E-02	7.65E-03	5.64E-02	2.20E-02	4.19E-02	1.85E-01	1.91E-01	3.75E-01
900000.	7.81E-04	1.73E-03	1.47E-03	1.58E-03	7.43E-04	5.48E-03	1.98E-03	4.07E-03	1.78E-02	1.65E-02	3.34E-02
1000000.	7.55E-05	1.57E-04	1.36E-04	1.52E-04	7.14E-05	5.31E-04	1.80E-04	3.94E-04	1.70E-03	1.47E-03	2.97E-03
TOTAL	1.23E 06	2.71E 06	2.31E 06	2.49E 06	1.17E 06	8.67E 06	3.10E 06	6.04E 06	2.83E 07	3.00E 06	3.13E 07

Appendix E

Table 4-2. (Case 32)

TABLE 4 - 2 : LOW POPULATION SCENARIO
NUMBER OF DEATHS PER TIME INTERVAL.(8260000.)

TIME	REPC	EDDY	REHD	MIDO	#TE	LEA	CHAV	REGB	TOT.ZONE	NON-SPEC	TTOTAL
0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
300.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
400.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
600.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
700.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
800.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
900.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1000.	2.17E 04	1.79E 04	1.05E 04	1.15E 04	5.11E 03	4.42E 04	1.51E 04	4.90E 04	1.75E 05	1.02E 05	2.79E 05
2000.	1.28E 05	1.21E 05	7.00E 04	7.40E 04	3.26E 04	2.72E 05	1.05E 05	2.70E 05	1.06E 06	2.06E 04	1.10E 06
3000.	9.01E 04	7.78E 04	4.59E 04	5.20E 04	2.29E 04	1.91E 05	6.72E 04	1.79E 05	7.26E 05	1.46E 04	7.41E 05
4000.	7.75E 04	6.49E 04	3.85E 04	4.47E 04	1.97E 04	1.64E 05	5.62E 04	1.48E 05	6.14E 05	1.42E 04	6.28E 05
5000.	6.92E 04	5.69E 04	3.40E 04	3.98E 04	1.76E 04	1.47E 05	4.91E 04	1.30E 05	5.42E 05	1.44E 04	5.58E 05
6000.	6.24E 04	5.07E 04	3.06E 04	3.60E 04	1.58E 04	1.32E 05	4.38E 04	1.16E 05	4.87E 05	1.51E 04	5.02E 05
7000.	5.66E 04	4.54E 04	2.73E 04	3.26E 04	1.44E 04	1.20E 05	3.92E 04	1.05E 05	4.40E 05	1.59E 04	4.56E 05
8000.	5.15E 04	4.03E 04	2.46E 04	2.97E 04	1.31E 04	1.09E 05	3.54E 04	9.53E 04	4.00E 05	1.67E 04	4.16E 05
9000.	4.71E 04	3.71E 04	2.24E 04	2.72E 04	1.20E 04	9.99E 04	3.20E 04	8.72E 04	3.65E 05	1.77E 04	3.83E 05
10000.	4.32E 04	3.37E 04	2.04E 04	2.49E 04	1.10E 04	9.17E 04	2.91E 04	7.99E 04	3.34E 05	1.86E 04	3.53E 05
20000.	2.87E 05	2.15E 05	1.32E 05	1.66E 05	7.30E 04	6.10E 05	1.86E 05	5.32E 05	2.20E 06	2.39E 05	2.44E 06
30000.	1.31E 05	8.74E 04	5.53E 04	7.54E 04	3.32E 04	2.78E 05	7.55E 04	2.42E 05	9.77E 05	2.90E 05	1.27E 06
40000.	6.59E 04	2.86E 04	2.56E 04	3.80E 04	1.67E 04	1.40E 05	3.36E 04	1.22E 05	4.80E 05	3.14E 05	7.94E 05
50000.	3.76E 04	2.12E 04	1.42E 04	2.17E 04	9.57E 03	7.99E 04	1.83E 04	6.95E 04	2.72E 05	3.03E 05	5.75E 05
60000.	2.30E 04	1.30E 04	8.93E 03	1.32E 04	5.83E 03	4.87E 04	1.18E 04	4.24E 04	1.67E 05	2.77E 05	4.44E 05
70000.	1.44E 04	9.54E 03	6.04E 03	8.29E 03	3.65E 03	3.05E 04	8.24E 03	2.66E 04	1.07E 05	2.45E 05	3.53E 05
80000.	9.12E 03	6.99E 03	4.25E 03	5.25E 03	2.31E 03	1.93E 04	6.04E 03	1.68E 04	7.01E 04	2.11E 05	2.82E 05
90000.	5.84E 03	5.26E 03	3.07E 03	3.37E 03	1.48E 03	1.24E 04	4.54E 03	1.08E 04	4.68E 04	1.80E 05	2.27E 05
100000.	3.84E 03	4.04E 03	2.27E 03	2.21E 03	9.77E 02	8.15E 03	3.49E 03	7.09E 03	3.21E 04	1.51E 05	1.83E 05
200000.	8.33E 03	1.15E 04	6.14E 03	4.79E 03	2.11E 03	1.77E 04	9.94E 03	1.54E 04	7.58E 04	4.76E 05	5.53E 05
300000.	7.15E 02	1.16E 03	6.03E 02	4.14E 02	1.62E 02	1.52E 03	1.00E 03	1.33E 03	6.92E 03	5.00E 04	5.69E 04
400000.	7.86E 01	1.04E 02	5.80E 01	4.52E 01	1.99E 01	1.66E 02	9.41E 01	1.45E 02	7.10E 02	4.41E 03	5.12E 03
500000.	8.18E 00	9.75E 00	5.35E 00	4.71E 00	2.07E 00	1.73E 01	8.43E 00	1.51E 01	7.09E 01	3.05E 02	4.36E 02
600000.	8.23E-01	8.64E-01	4.86E-01	4.75E-01	2.10E-01	1.75E 00	7.46E-01	1.52E 00	6.80E 00	2.95E 01	3.64E 01
700000.	8.20E-02	7.65E-02	4.42E-02	4.72E-02	2.08E-02	1.74E-01	6.61E-02	1.51E-01	6.62E-01	2.37E 00	3.03E 00
800000.	8.04E-03	6.84E-03	4.04E-03	4.63E-03	2.04E-03	1.70E-02	5.90E-03	1.48E-02	6.34E-02	1.91E-01	2.54E-01
900000.	7.81E-04	6.15E-04	3.71E-04	4.50E-04	1.98E-04	1.66E-03	5.31E-04	1.44E-03	6.04E-03	1.55E-02	2.16E-02
1000000.	7.55E-05	5.58E-05	3.43E-05	4.35E-05	1.92E-05	1.60E-04	4.82E-05	1.40E-04	5.77E-04	1.27E-03	1.85E-03
TOTAL	1.23E 06	9.62E 05	5.82E 05	7.11E 05	3.13E 05	2.62E 06	8.31E 05	2.35E 06	9.60E 06	3.00E 06	1.20E 07

Appendix E

Table 5-1. (Case 32)

TABLE 5 - 1 : TOTAL UNDISCOUNTED DAMAGES FOR EACH ZONE FOR EACH TIME INTERVAL - HIGH POPULATION

TIME	REPC	EDDY	HELO	MIDO	WTE	LEA	CHAV	REGB	TOT.ZONE	NON-SPEC	TTOTAL
0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
300.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
400.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
600.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
700.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
800.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
900.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1000.	5.05E 09	1.31E 10	1.09E 10	1.05E 10	4.98E 09	3.81E 10	1.47E 10	3.60E 10	1.24E 11	2.00E 10	1.60E 11
2000.	3.34E 10	8.90E 10	7.24E 10	6.73E 10	3.18E 10	2.54E 11	1.02E 11	2.04E 11	8.34E 11	5.42E 09	8.39E 11
3000.	2.34E 10	5.70E 10	4.74E 10	4.73E 10	2.23E 10	1.65E 11	6.52E 10	1.31E 11	5.58E 11	3.85E 09	5.62E 11
4000.	2.02E 10	4.70E 10	3.98E 10	4.07E 10	1.92E 10	1.41E 11	5.45E 10	1.09E 11	4.72E 11	3.69E 09	4.76E 11
5000.	1.80E 10	4.17E 10	3.51E 10	3.62E 10	1.71E 10	1.26E 11	4.77E 10	9.53E 10	4.17E 11	3.75E 09	4.21E 11
6000.	1.62E 10	3.72E 10	3.13E 10	3.27E 10	1.54E 10	1.14E 11	4.25E 10	8.52E 10	3.74E 11	3.92E 09	3.78E 11
7000.	1.47E 10	3.33E 10	2.82E 10	2.97E 10	1.40E 10	1.03E 11	3.81E 10	7.70E 10	3.38E 11	4.13E 09	3.42E 11
8000.	1.34E 10	2.99E 10	2.55E 10	2.70E 10	1.28E 10	9.40E 10	3.43E 10	7.00E 10	3.07E 11	4.35E 09	3.11E 11
9000.	1.23E 10	2.72E 10	2.31E 10	2.48E 10	1.17E 10	8.60E 10	3.11E 10	6.40E 10	2.80E 11	4.55E 09	2.85E 11
10000.	1.12E 10	2.47E 10	2.11E 10	2.27E 10	1.07E 10	7.89E 10	2.82E 10	5.86E 10	2.56E 11	4.85E 09	2.61E 11
20000.	7.47E 10	1.59E 11	1.36E 11	1.51E 11	7.11E 10	5.25E 11	1.81E 11	3.90E 11	1.69E 12	6.21E 10	1.75E 12
30000.	3.40E 10	6.41E 10	5.71E 10	6.86E 10	3.24E 10	2.39E 11	7.33E 10	1.77E 11	7.46E 11	7.71E 10	8.23E 11
40000.	1.71E 10	2.63E 10	2.64E 10	2.45E 10	1.63E 10	1.20E 11	3.26E 10	8.93E 10	3.65E 11	8.17E 10	4.47E 11
50000.	9.79E 09	1.56E 10	1.46E 10	1.98E 10	9.32E 09	6.88E 10	1.78E 10	5.10E 10	2.07E 11	7.88E 10	2.85E 11
60000.	5.57E 09	9.57E 09	9.23E 09	1.20E 10	5.68E 09	4.20E 10	1.14E 10	3.11E 10	1.27E 11	7.19E 10	1.99E 11
70000.	3.74E 09	7.09E 09	6.24E 09	7.54E 09	3.56E 09	2.63E 10	8.00E 09	1.95E 10	8.13E 10	6.38E 10	1.46E 11
80000.	2.37E 09	5.12E 09	4.34E 09	4.77E 09	2.25E 09	1.66E 10	5.86E 09	1.24E 10	5.27E 10	5.50E 10	1.09E 11
90000.	1.52E 09	3.85E 09	3.17E 09	3.07E 09	1.45E 09	1.07E 10	4.41E 09	7.93E 09	3.61E 10	4.67E 10	8.28E 10
100000.	9.98E 08	2.96E 09	2.25E 09	2.01E 09	9.52E 08	7.01E 09	3.39E 09	5.21E 09	2.49E 10	3.92E 10	6.41E 10
200000.	2.16E 09	8.42E 09	6.34E 09	4.36E 09	2.06E 09	1.52E 10	9.04E 09	1.13E 10	5.55E 10	1.24E 11	1.84E 11
300000.	1.06E 08	6.40E 08	6.23E 08	3.70E 08	1.78E 08	1.31E 09	9.72E 08	9.73E 08	5.46E 09	1.30E 10	1.85E 10
400000.	2.04E 07	7.98E 07	6.60E 07	4.11E 07	1.94E 07	1.43E 08	9.13E 07	1.06E 08	5.62E 08	1.15E 09	1.71E 09
500000.	2.13E 06	7.15E 06	5.53E 06	4.23E 06	2.02E 06	1.49E 07	8.13E 06	1.11E 07	5.53E 07	9.48E 07	1.50E 08
600000.	2.14E 05	6.34E 05	5.03E 05	4.32E 05	2.04E 05	1.51E 06	7.24E 05	1.12E 06	5.23E 06	7.66E 06	1.30E 07
700000.	2.13E 04	5.61E 04	4.57E 04	4.30E 04	2.03E 04	1.49E 05	6.41E 04	1.11E 05	5.11E 05	6.15E 05	1.13E 06
800000.	2.05E 03	5.01E 03	4.18E 03	4.21E 03	1.99E 03	1.47E 04	5.73E 03	1.09E 04	4.88E 04	4.98E 04	9.85E 04
900000.	2.03E 02	4.51E 02	3.83E 02	4.10E 02	1.93E 02	1.43E 03	5.15E 02	1.06E 03	4.64E 03	4.94E 03	8.68E 03
1000000.	1.96E 01	4.09E 01	3.54E 01	3.96E 01	1.87E 01	1.38E 02	4.68E 01	1.03E 02	4.42E 02	5.30E 02	7.72E 02
TOTAL	3.21E 11	7.35E 11	6.31E 11	6.47E 11	3.05E 11	2.25E 12	8.06E 11	1.73E 12	7.37E 12	7.80E 11	8.15E 12

Appendix E

Table 5-2. (Case 32)

TABLE 5 - 2 : TOTAL UNDISCOUNTED DAMAGES FOR EACH ZONE FOR EACH TIME INTERVAL - LOW POPULATION

TIME	REPO	EDDY	REBD	MIDD	WTE	LEA	CHAV	REGB	TOT.ZONE	NON-SPEC	TTOTAL
0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
300.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
400.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
600.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
700.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
800.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
900.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1000.	5.65E 09	4.64E 09	2.73E 09	2.99E 09	1.33E 09	1.15E 10	3.94E 09	1.28E 10	4.55E 10	2.66E 10	7.22E 10
2000.	3.34E 10	3.15E 10	1.82E 10	1.92E 10	8.47E 09	7.08E 10	2.73E 10	7.22E 10	2.81E 11	5.42E 09	2.87E 11
3000.	2.34E 10	2.02E 10	1.19E 10	1.35E 10	5.96E 09	4.97E 10	1.75E 10	4.64E 10	1.89E 11	3.85E 09	1.93E 11
4000.	2.02E 10	1.69E 10	1.00E 10	1.16E 10	5.12E 09	4.27E 10	1.46E 10	3.85E 10	1.60E 11	3.69E 09	1.63E 11
5000.	1.80E 10	1.48E 10	8.83E 09	1.04E 10	4.57E 09	3.82E 10	1.28E 10	3.37E 10	1.41E 11	3.75E 09	1.45E 11
6000.	1.62E 10	1.32E 10	7.89E 09	9.35E 09	4.12E 09	3.44E 10	1.14E 10	3.02E 10	1.27E 11	3.92E 09	1.31E 11
7000.	1.47E 10	1.18E 10	7.09E 09	8.48E 09	3.73E 09	3.12E 10	1.02E 10	2.73E 10	1.15E 11	4.13E 09	1.19E 11
8000.	1.34E 10	1.06E 10	6.41E 09	7.71E 09	3.40E 09	2.84E 10	9.19E 09	2.48E 10	1.04E 11	4.35E 09	1.08E 11
9000.	1.23E 10	9.64E 09	5.81E 09	7.07E 09	3.11E 09	2.60E 10	8.33E 09	2.27E 10	9.49E 10	4.59E 09	9.95E 10
10000.	1.12E 10	8.77E 09	5.30E 09	6.48E 09	2.86E 09	2.38E 10	7.57E 09	2.08E 10	8.68E 10	4.85E 09	9.17E 10
20000.	7.47E 10	5.60E 10	3.43E 10	4.31E 10	1.90E 10	1.59E 11	4.84E 10	1.38E 11	5.72E 11	6.21E 10	6.34E 11
30000.	3.40E 10	2.27E 10	1.44E 10	1.96E 10	8.64E 09	7.22E 10	1.96E 10	6.28E 10	2.54E 11	7.71E 10	3.31E 11
40000.	1.71E 10	1.01E 10	6.65E 09	9.87E 09	4.35E 09	3.63E 10	8.74E 09	3.16E 10	1.25E 11	8.17E 10	2.06E 11
50000.	9.79E 09	5.52E 09	3.68E 09	5.65E 09	2.49E 09	2.08E 10	4.77E 09	1.81E 10	7.07E 10	7.88E 10	1.49E 11
60000.	5.97E 09	3.54E 09	2.32E 09	3.44E 09	1.52E 09	1.27E 10	3.06E 09	1.10E 10	4.25E 10	7.19E 10	1.15E 11
70000.	3.74E 09	2.48E 09	1.57E 09	2.16E 09	9.50E 08	7.93E 09	2.14E 09	6.91E 09	2.79E 10	6.38E 10	9.17E 10
80000.	2.37E 09	1.82E 09	1.10E 09	1.36E 09	6.01E 08	5.02E 09	1.57E 09	4.36E 09	1.82E 10	5.50E 10	7.32E 10
90000.	1.52E 09	1.37E 09	7.97E 08	8.76E 08	3.86E 08	3.22E 09	1.18E 09	2.81E 09	1.22E 10	4.67E 10	5.89E 10
100000.	9.98E 08	1.05E 09	5.91E 08	5.75E 08	2.54E 08	2.12E 09	9.07E 08	1.84E 09	8.34E 09	3.92E 10	4.75E 10
200000.	2.16E 09	2.99E 09	1.63E 09	1.24E 09	5.49E 08	4.59E 09	2.58E 09	4.03E 09	1.67E 10	1.24E 11	1.44E 11
300000.	1.86E 08	3.01E 06	1.57E 08	1.08E 08	4.74E 07	3.95E 08	2.60E 08	3.45E 08	1.80E 09	1.30E 10	1.48E 10
400000.	2.04E 07	2.83E 07	1.51E 07	1.17E 07	5.18E 06	4.32E 07	2.45E 07	3.77E 07	1.86E 08	1.15E 09	1.33E 09
500000.	2.13E 06	2.54E 06	1.39E 06	1.22E 06	5.39E 05	4.50E 06	2.19E 06	3.92E 06	1.84E 07	9.48E 07	1.13E 08
600000.	2.14E 05	2.25E 05	1.26E 05	1.24E 05	5.45E 04	4.55E 05	1.94E 05	3.96E 05	1.79E 06	7.66E 06	9.45E 06
700000.	2.13E 04	1.99E 04	1.15E 04	1.23E 04	5.40E 03	4.51E 04	1.72E 04	3.93E 04	1.72E 05	6.15E 05	7.87E 05
800000.	2.09E 03	1.78E 03	1.05E 03	1.20E 03	5.30E 02	4.43E 03	1.54E 03	3.86E 03	1.65E 04	4.96E 04	6.61E 04
900000.	2.03E 02	1.60E 02	9.65E 01	1.17E 02	5.15E 01	4.30E 02	1.38E 02	3.75E 02	1.57E 03	4.04E 03	5.61E 03
1000000.	1.96E 01	1.45E 01	8.91E 00	1.13E 01	4.99E 00	4.17E 01	1.25E 01	3.63E 01	1.50E 02	3.30E 02	4.80E 02
TOTAL	3.21E 11	2.50E 11	1.51E 11	1.85E 11	8.14E 10	6.81E 11	2.16E 11	6.11E 11	2.50E 12	7.80E 11	3.28E 12

GLOSSARY

damages — the value of adverse or unwanted effects measured in economic units, usually dollars. Total damages are a summation over causes and time; marginal damages are total damages divided by a reference production quantity.

diapir — a mobile core such as salt which moves upward injecting into the more brittle overlying rock.

diatreme — a volcanic vent or pipe, typically less than 1000 m in diameter, drilled through enclosing rocks by the explosive energy of gas-charged magmas (mobile, possibly molten, rock material).

distribution coefficient (K_d) — a sorption parameter relating amount of material sorbed on solid material and amount remaining in solution.

dose — "committed dose equivalent" is sometimes referred to here as simply "dose." Dose equivalent is the product of the absorbed dose from radioactivity and the quality factor, loosely called biological dose, expressed in units of rem or millirem (mrem). Committed dose is the sum of future dose accrual (generally over 50 y) resulting from a radioactivity intake. Dose expressed in man-rems is the sum of dose to individuals in a given population.

dose rate — the rate at which dose (committed dose equivalent) accrues following an intake or during exposure to an external source. Where an intake rate is also involved, reference is made here to "dose committment rate" (committed dose equivalent rate).

health effect — an unwanted health effect such as leukemia, a cancer, or serious genetic effect, equatable to a death for damage estimation purposes.

leach incident — a combination of events that introduces circulating ground water to the waste inventory and starts dissolving waste components. Time delays for the leach process and migration via ground water flow retard the environmental effects.

local dose — committed dose equivalent to individuals located in a given geographic zone, in mrem.

nonspecific dose	committed dose equivalent to an undefined population from consumption of largely exported agricultural products, in man-rem.
nuclide	a nuclear species characterized by the number of neutrons and protons in the nucleus. Used here at times in lieu of the more descriptive term: radionuclide.
offset faulting	movement producing relative displacement of adjacent rock masses along a fracture and resulting in a separation or gap.
probabilistic	based on probability, which is the number of times something will probably occur in a given amount of time. The probabilistic mode refers to operations with probabilities included in the calculations.
radionuclide	a nuclide which is unstable or radioactive.
release	a breach of containment which allows radioactive material to migrate through the geosphere. A release may or may not be directly to the biosphere.
resuspension	the process of material deposited onto land surface being picked up by wind action and resuspended.
risk	The product of probability of occurrence of an event and the consequences of an occurrence. As used in economics, risk refers to the chance of damage or loss.
sorption	an overall term referring to retention of a species on a solid by any of several processes such as absorption, adsorption, and ion exchange.
volcanic, volcanism	adjective and noun, respectively, pertaining to natural processes resulting in the formation of volcanoes or lava flows.
volcanic explosion	a violent explosive form of volcano ejecting material into the atmosphere.
volcanogenic transport	non-explosive carrying of material by any of three mechanisms: magma transport, volatile transport, or hydrothermal transport.

VOLUME III

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